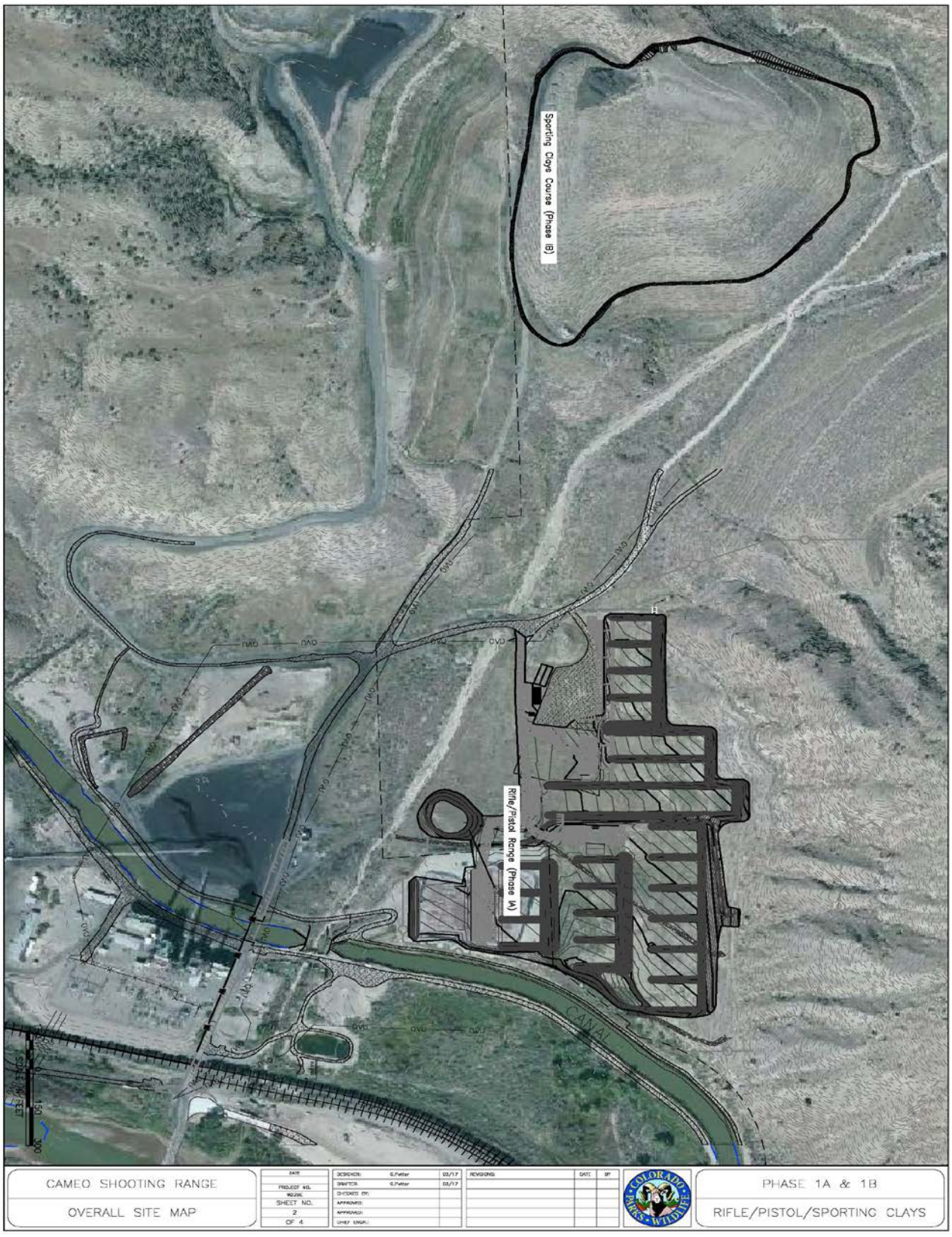
APPENDIX A – Map of Part One (Phase 1a and 1b Range Areas) & Phase 1a Detail



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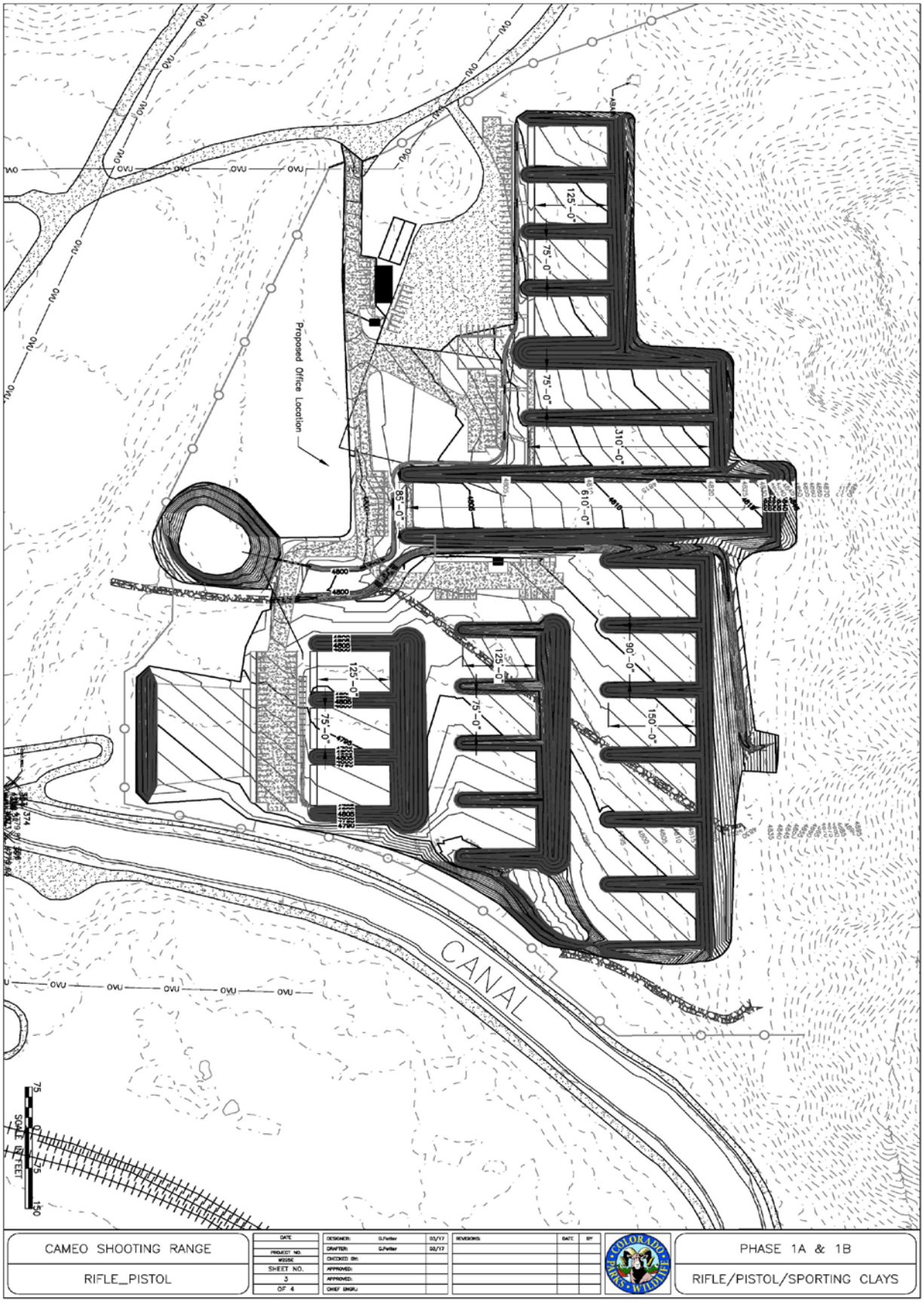


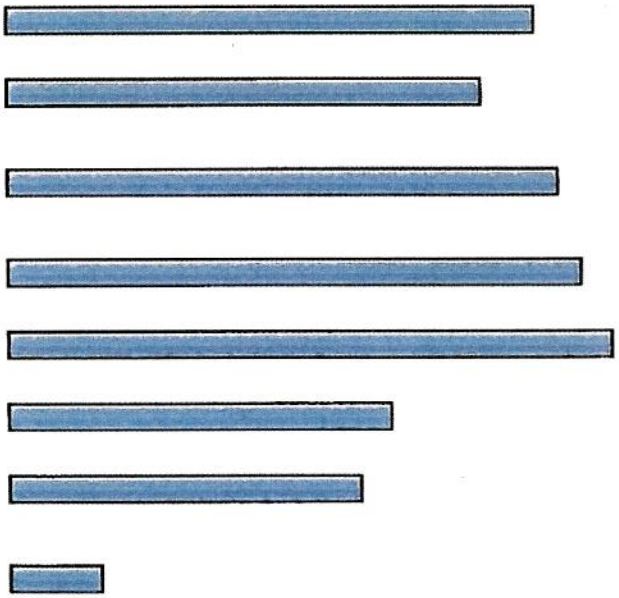
CAMEO SHOOTING RANGE	DATE	DESIGNER: G.Fetter 03/17	REVISIONS:	DATE	BY	COLORADO PARKS • WILDLIFE	PHASE 1A & 1B
	PROJECT NO.	DRAFTER: G.Fetter 03/17					
RIFLE_PISTOL	92256	CHECKED By:					RIFLE/PISTOL/SPORTING CLAYS
	SHEET NO.	APPROVED:					
	3 OF 4	APPROVED:					
		CHIEF ENGR.:					

Cameo Shooting Complex Survey

1. Do you support Colorado Parks and Wildlife building a shooting sports and education complex in the Grand Valley?

	Response Percent	Response Count
Yes	**95.5%**	**903**
No	2.6%	25
I am not sure.	1.9%	18
answered question		**946**
skipped question		**6**

2. What types of amenities would you like to see available at a shooting sports and education complex in the Grand Valley? (Please check all that apply.)

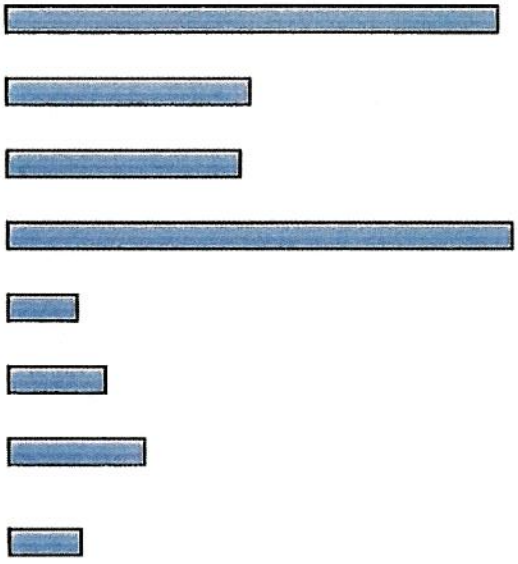


	Response Percent	Response Count
Indoor Classrooms	82.2%	739
Outdoor Classrooms	73.7%	663
Indoor Archery, Handgun and Rifle Ranges	85.9%	772
Target and Competition Ranges	89.4%	804
Sighting-in and Practice Ranges	**94.4%**	**849**
Law Enforcement Training Ranges	59.7%	537
3-D Archery Ranges	54.7%	492
Other (please specify)	13.7%	123
answered question		**899**
skipped question		**53**

3. If a shooting sports and education facility were built in the Grand Valley, would you use it?

	Response Percent	Response Count
Yes	**90.1%**	**808**
No	1.7%	15
I am not sure.	8.2%	74
answered question		**897**
skipped question		**55**

4. Which of the following categories would best describe your interest in a shooting sports and education facility in the Grand Valley? (Please check all that apply.)



	Response Percent	Response Count
Hunter	77.2%	691
Angler	38.1%	341
Archer	36.2%	324
Sport Shooter	**78.9%**	**706**
Law Enforcement	10.4%	93
Educator	15.0%	134
Self-defense Trainer	21.0%	188
Other (please specify)	10.7%	96
answered question		**895**
skipped question		**57**

5. In which Colorado county do you live? (If you live outside of Colorado, please enter your state.)

	Response Count
	900
answered question	**900**
skipped question	**52**

6. What is your gender?

		Response Percent	Response Count
Female		22.5%	205
Male		**77.5%**	**708**
		answered question	**913**
		skipped question	**39**

Who Will Use This Facility

Law Enforcement/ Military/ National Guard

Colorado Parks and Wildlife
Town of Palisade Police Department
City of Grand Junction Police
Fruita Police
Mesa County Sheriff
Colorado State Patrol
Collbran Marshal
DeBeque Marshal
NSF Officers
District 51 School Safety officers
U.S. Bureau of Land management
U.S. Forest Service
Colorado Bureau of Investigations
FBI / Immigration/ IRS

Leadership Training

Montrose County Achievement Program
Ouray County Achievement Program
Mesa County Achievement Program
Delta County Achievement Program
Colorado 4-H Leader Forum
Ambassador Training Program
Sportsman Caucus Committee

Colorado State University Extension WHEP Program

(Environmental Sciences and Lifetime Physical Activities)

Hunting Knowledge Workshops

Turkey 101
Deer hunting 101
Upland Bird Hunting 101
Waterfowl Hunting 101
Elk Hunting 101
Marksmanship 101
BAI Training for teachers

Shooting Specialty Leadership Training (NSSF & NRA)

Nationals Instructorship
Archery, Shotgun, Air Rifle, 22 LR, Pistol, RSO, Outdoor Survival

Outdoor Skills Workshops

Wholesome Meat Handling Class
Leather craft Workshops
Shooting, climbing, outdoor skills
Marketing Classes

Shooting Competitions

4-H Shooting Sports in rifle, archery
Cowboy Shots
Archery – Field Target Competition
Archery – 3-D Target Competition
Crossbow – Field Target Competition
Black Powder Competitions
Pistol - Short Range / Long Range Competitions
Rifle – Short Range and Long Range Competitions
Trap Shooting Competitions
Skeet Shooting Competitions
Sporting Clays Competitions

Outdoor Educational Users (School District 51 and CPW)

Environmental Science, Outdoor Skills, and Hunter Safety are in the curriculum.
Teacher certifications, and training in progress. NRA, BAI, IHEA, TENS.
Instructor and Volunteer Processing (Background checks, Safety training: Red Cross First Aid and Emergency Response)
District 51 Summer School courses

Huntmaster Training / Hunter Safety Classes and Instructorship

Huntmaster Certification
Hunter Safety Classes
Hunter Safety for Teachers
New Instructor Academy

BLM EFF (Wildland Fire Training)

Basic Fire Fighting
Basic Fire Weather
Mesa County Public Safety Program

APPENDIX

CAMEO Shooting Complex Construction Specifications

Construction Activities	Description	Specifications
Cross slopes for Ranges and Parking Areas	Graded moderately northwest to southeast at 2% to accommodate ADA activity across project area	Grading plan will consist of cuts up to 15' and fill areas up to 11'; will drain to retention ponds
Parking Lot Area	150 identified spaces with smaller, general parking lot areas for special events	Constructed of recycled asphalt (CDOT); drainage will continue to be directly to nearby channel
Impervious Areas	Shooting lane concrete pads, 2 group picnic areas, a modular building concrete pad, a storage building, and 2 vault toilets	Approximately 22,000 sq. ft.; current impervious is 0% and final will be approximately 2%
Disturbed Areas	Ranges, access roads, building sites, etc	Approximately 1,017,676 sq. ft.
2 Detention/Retention Ponds	1) Retention pond to maintain water quality of Phase 1A ranges near entrance 2) Detention pond to maintain water quality of other ranges on south side of the project site	1) Capacity will be increased from 2 acre-ft to 7.7 acre-ft (greater than 100 yr. estimated runoff event) 2) Capacity will be increased from 3 acre-ft to 6.5 acre-ft (greater than 100 yr. estimated runoff event)
Lead Reclamation Plan	Based on the health and safety of the shooters. Amount of lead shot buildup will be regularly monitored & reclaimed when necessary	Water quality control measures used to monitoring proper pH levels of the soil and the ponds. Vegetation will be planted that are NOT food sources for local avian species.
Vault Toilets	2 to be located at the Main Phase 1a Public Range near the entrance	Double units @ 130 sq ft foot print each.
Stormwater Control	SWMP from the State will be required of contractor chosen	Contractor will likely use erosion control BMPs such as silt fences, straw waddles, and other standard techniques
Potential Toxic Runoff	Previous industrial uses of the project site could create toxic runoff events during construction	Rare Earth is under contract to insure no such events occur during project site construction activities; no cutting will be allowed in old spray pond locations, only fill can be placed within the limits of the ponds.
Berms		

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Proposed Cameo Shooting-Range Facility – Site Area Descriptions

Mesa County, Colorado

August 31, 2016

Specific area descriptions are presented below for both the Snowcap and Xcel parcels ("Site"). Color coding represents the expected level of environmental concern, and whether or not a specific area is available for further design ideas by CPW. For example:

GREEN = Areas determined to be of low environmental concern

YELLOW = Areas recommended for further investigation (i.e., Phase II ESA)

RED = Areas to avoid (i.e., subject to environmental convents and/or Xcel-owned)

However, this color-coding scheme is not intended to represent levels of engineering or geotechnical concern, even though some relevant information is provided below (e.g., areas with known burial of coal waste, concrete rubble, etc. – known areas that could present a building-engineering challenge).

A. Snowcap Coal Mine-Permit Boundary (Permit No. C-1981-041) – The Site includes approximately 100 acres of reclaimed areas related to Snowcap's former coal-mining operations.

A1. Bulk of Snowcap Reclaimed Areas (88 acres)

A2. Remaining Bond-Release Areas (12.2 acres)

- ***Environmental Concern***: Limited
- ***Environmental Action***: Approximately 12.2 acres remain to be bond-released by DRMS; proposed post-mining land-use change (from fish & wildlife to industrial) in the works by Snowcap. Therefore, these areas are off-limits for the time being.
- ***Engineering Concern***: Two large coal-refuse disposal areas (CRDAs [No. 1 = 15 acres / No. 2 = 20 acres]) that are capped/revegetated/contoured with only 1.5 to 2.0 feet of cover material; abandoned underground coal-mine workings; etc.

B. Xcel-Retained Parcels

B1. UMTRA Concrete Mine Portal (0.02 acre)

- ***Environmental Concern***: Has an environmental covenant. Radiologically-contaminated concrete foundation near the original Cameo mine portal. Activity restrictions include:

    1. No habitable structure may be constructed without properly designed radon mitigation as approved by CDPHE.
    2. No well, hole, pipe, channel or other device that is or may be used to withdraw, extract or otherwise access groundwater shall be constructed, installed, operated or maintained in the uppermost alluvial aquifer.
    3. No tilling, excavation, grading, construction or any other activity that disturbs the ground surface is permitted, without the express written consent of CDPHE and DOE.

- ***Action*:** Avoid this area

B2. Coal-Unloading Area (6.7 acres)

- ***Environmental Concern***: Has an environmental covenant. Residual coal remains in the area and as embankment fill; elevated lead and arsenic levels in soil samples; embankment graded and filled in part by using recycled non-UMTRA concrete from powerplant demolition. Activity restrictions include:

    1. The soil cover shall be protected. No excavation, drilling, grading, digging, tilling or any other soil-disturbing activity is permitted on the property unless approved by CDPHE. Any disturbed areas shall have a minimum of 2 feet of soil cover and re-vegetation afterwards.
    2. Access roads shall be constructed with a preference for fill, rather than cut soil balance.
    3. At such time as access roads are constructed or other earthwork undertaken on the property, additional soil cover shall be placed and revegetated in the areas identified by CDPHE.
    4. Groundwater wells are allowed, but solid cased (no screen) through residual coal.

- ***Action*:** Avoid this area

B3. Drainage Facilities (2.4 acres) – Xcel owns the stormwater channel and detention pond ("Drainage Facilities") associated with the adjoining 35-acre Ash Disposal Facility (ADF), which is regulated by CDPHE, and Xcel has a 30-year post-closure monitoring obligation for the ADF and associated drainage facilities.

- ***Environmental Concern***: Has an environmental covenant. Activity restrictions include:
    1. The integrity of the channel and pond shall be maintained in the as built configuration, per the September 30, 2011 *Final Drainage Report* for the Cameo Decommissioning Project, prepared by Wright Water Engineers (WWE).

2. Conduct routine inspections and maintenance of the channel and pond and make necessary repairs as needed to maintain function and capacity.
3. The channel and pond may be modified or relocated only upon approval by CDPHE of the proposed new configuration and design. Any new design shall at a minimum meet the capacity requirements identified in the WWE design.

- ***Action*:** Avoid this area

B4. Former Powerplant Area (12.925 acres) – Xcel retains the old powerplant area which includes an operable electrical substation.

- ***Environmental Concern***: Buried UMTRA-concrete footings and foundations; and, possible unresolved subsurface and groundwater PCB, solvent, and/or hydrocarbon contamination.

- ***Action*:** Avoid this area

C. Other Former Xcel-Occupied Areas – these are areas considered "clean-closed" by CDPHE as of July 2015 as part of Xcel's decommissioning program for the Cameo Station.

C1. Coal Pile (3.5 acres)

- ***Environmental Concern***: Limited. Approximately 5,000 cubic-yards of residual coal excavated up to 2 feet below existing grade; soil samples collected; closure standards met; 2 feet of clean soil placed over the area.

- ***Environmental Action*:** None recommended

C2. Detention Pond (0.3 acre)

- ***Environmental Concern***: Limited. Soil samples collected; closure standards met; 2 feet of clean soil placed over the area.

- ***Environmental Action*:** None recommended

- ***Engineering Concern***: Area was filled and compacted to surrounding grade using excess rock and in-situ borrowed soil. The rock was previously mined and screened on Site.

C3. Retention Pond (0.05 acre)

- ***Environmental Concern***: Limited. Soil samples collected; closure standards met; lined with excess rock previously mined and screened on Site. Serves as a detention pond/infiltration ditch for non-contact stormwater runoff from the Site; designed to overflow to Coal Creek during high runoff events.

- ***Environmental Action*:** None recommended

C4. Spray Pond (0.78 acre)

- ***Environmental Concern***: Soil samples collected; closure standards met. However, during excavation and removal of the pond liner, coal ash was observed on the pond bottom and in the perimeter berm: the ash was apparently used as subgrade material beneath the liner. Coal ash left in place.

- ***Engineering Concern***: Area was filled and compacted to surrounding grade using excess rock previously mined and screened on Site; recycled non-UMTRA concrete rubble generated during powerplant demolition; and excess clean soil borrowed on Site. Coal ash left in place, as described above.

- ***Environmental Action*:** Phase II ESA to excavate test pits or bore soils to evaluate polycyclic aromatic hydrocarbons (PAHs) and metals.

C5. Coal Pile Runoff Pond (0.08 acre) – previously excavated and now encompassed by ADF stormwater detention pond (described above under B3 ["Drainage Facilities"]).

D. Former Solar Array Area

D1. Former Solar Array (6.3 acres)

- ***Environmental Concern***: Located downgradient relative to the Xcel powerplant footprint and the coal-unloading area subject to an environmental covenant, and downgradient from areas where commingled-waste (Deposit AH: containing uraniferous coal, elevated lead and cadmium levels in soil, and other radiological contamination) and a former warehouse septic leachfield were previously identified.

- ***Environmental Action***: Phase II ESA to install groundwater monitoring wells along the north boundary of the former solar array in order to collect soil and groundwater samples for laboratory analysis of potential hydrocarbon compounds, metals, PCBs, SVOCs, VOCs, etc.

E. Old Coal-Ash Piles

E1. Coal-Ash Pile No. 1 – located between Coal Creek and main access Road I.9.
E2. Coal-Ash Pile No. 2 – located north-northwest of former solar array (Area D1)

- ***Environmental Concern***: Residual coal ash and/or coal waste was dumped on the ground surface or used in embankments at the Site.

- ***Environmental Action***: Phase II ESA to sample and laboratory-analyze (e.g., sulfur & nitrogen compounds, metals, PAHs, etc.) to evaluate whether formal disposal (or containment, avoidance, etc.) of these piles is required.

F. Additional Targeted Phase II ESA Areas (To Be Determined)

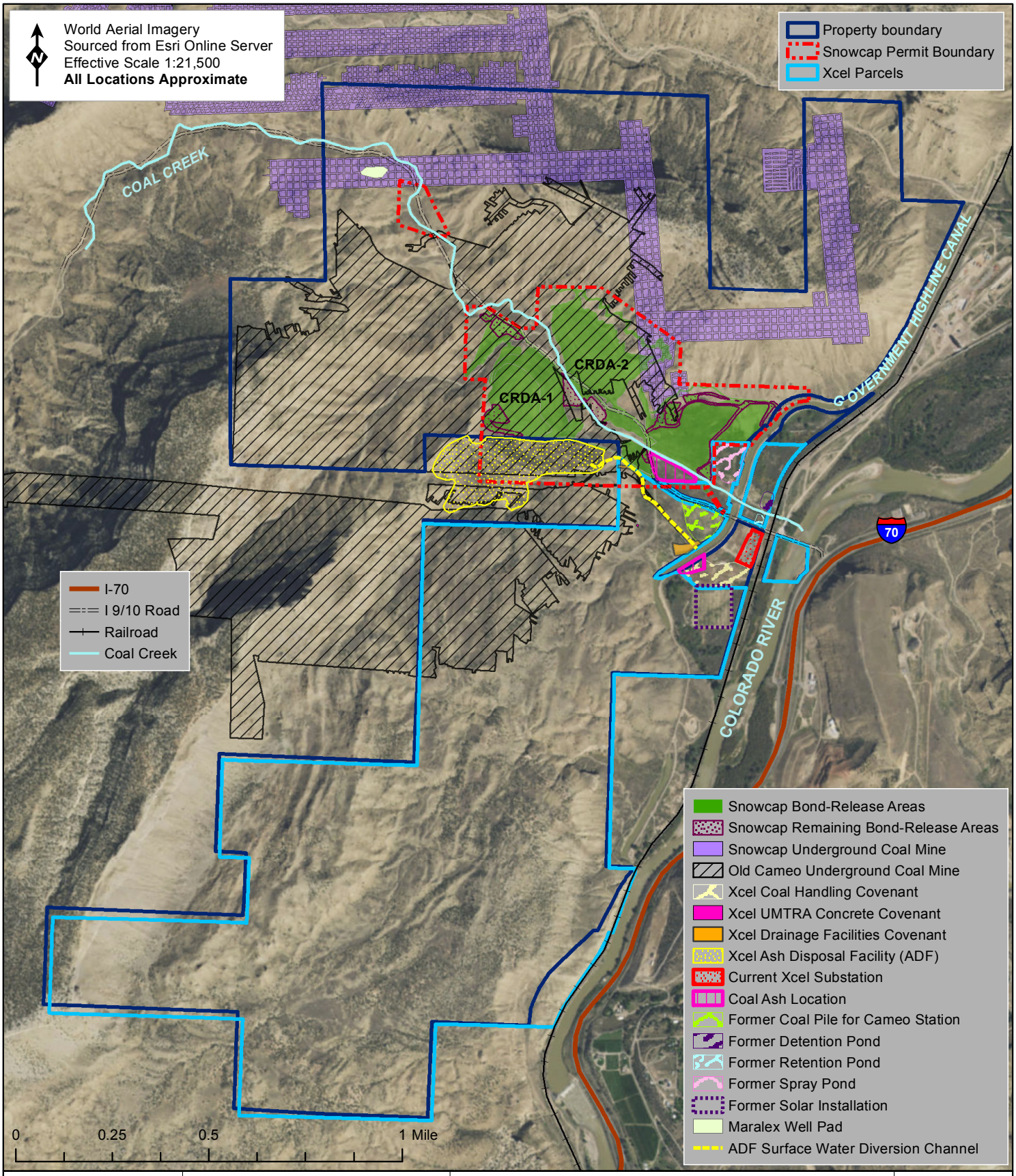
- ***Environmental Concern***: Due to the historic industrial usage at the Site (along with the former Cameo townsite location), the possibility exists for undiscovered solid-waste materials (e.g., buried steel/concrete/wood debris, undocumented coal-ash or coal-waste disposal areas, etc.) or petroleum hydrocarbon contamination in the subsurface (e.g., resulting from previous decommissioning of ASTs or USTs).

- ***Environmental Action***: Phase II ESA. To be determined. These are areas where CPW proposes to erect new structures or construct roads, utility corridors, public-use facilities, or other infrastructure. CDPHE (Mike Cosby: 970/248-7171) should be contacted for gamma-radiation surveys in those areas of the Site where new construction/development is proposed by CPW in order to evaluate the presence of residual radioactive materials.

G. Subsidence

- ***Engineering Concern***: A portion of the Site in Sections 20, 21, 27, 28, 32, 33 and 34 is undermined by former workings of the original Cameo Mine and the Snowcap Roadside North Mine.

- ***Engineering Action*:** It is recommended that a Subsidence Study be prepared for those areas, at a minimum, where CPW plans to construct permanent buildings, hard surfaces, utility corridors, irrigation systems, etc. A subsidence study evaluates the proximity and height/width/depth to underground workings, bulking factors, angle of draw, lithology and strength of strata overlying the workings, groundwater fluctuations, and other geologic conditions.



DATE: June 2016

DRAWN BY: D. Reeder

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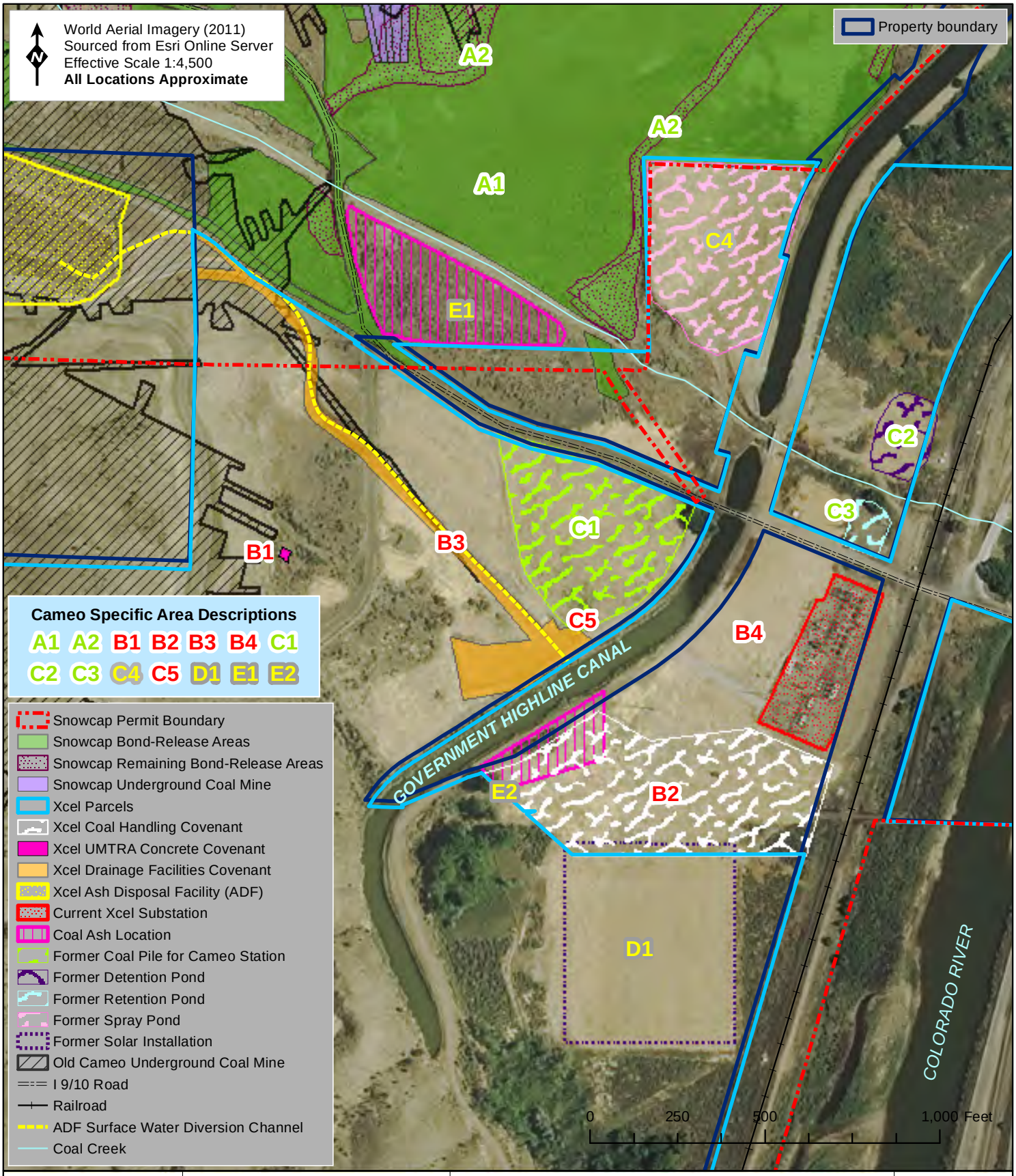
CAMEO SHOOTING COMPLEX FEATURES DETAIL

CPW PROJECT NO. 14-084-NW
Mesa County, Colorado

FIGURE 1



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CAMEO SHOOTING COMPLEX FEATURES DETAIL

CPW PROJECT NO. 14-084-NW
Mesa County, Colorado

FIGURE 2

APPENDIX D –

Period of Record Monthly Climate Summary for Grand Junction (Period of Record: 1/ 1/1900 to 12/31/2005)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
Average Max. Temperature (F)	36.7	44.7	55.1	65.1	75.6	86.8	92.7	89.4	80.6	67.4	51.1	39.0	**65.3**
Average Min. Temperature (F)	16.0	23.3	31.2	39.3	48.3	57.2	64.1	62.0	53.0	41.1	28.3	18.7	**40.2**
Average Total Precipitation (in.)	0.60	0.57	0.83	0.79	0.79	0.44	0.61	0.99	0.95	0.90	0.64	0.57	**8.70**
Average Total SnowFall (in.)	6.0	3.8	3.0	0.9	0.1	0.0	0.0	0.0	0.0	0.4	2.4	4.9	**21.6**
Average Snow Depth (in.)	1	1	0	0	0	0	0	0	0	0	0	1	**0**

SOIL SURVEY OF

Mesa County Area, Colorado

United States Department of Agriculture
Soil Conservation Service

In cooperation with
Colorado Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1959–69. Soil names and descriptions were approved in 1970. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1969. This survey was made cooperatively by the Soil Conservation Service and the Colorado Agricultural Experiment Station. It is part of the technical assistance furnished to the Mesa Soil Conservation District. Financial assistance for the survey of the Colorado National Monument part was provided by the National Park Service, U.S. Department of the Interior.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, and wildlife areas; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Mesa County Area are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the range site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units.

Wildlife managers and others can find information about soils and wildlife in the section "Wildlife."

Ranchers and others can find, under "Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

Community planners and others can read about soil properties that affect the choice of sites for nonindustrial buildings and for recreation areas in the engineering section.

Engineers and builders can find, under "Engineering," tables that contain estimates of soil properties and information about soil features that affect engineering practices.

Scientists and others can read about the soils in the section "Formation and Classification of the Soils."

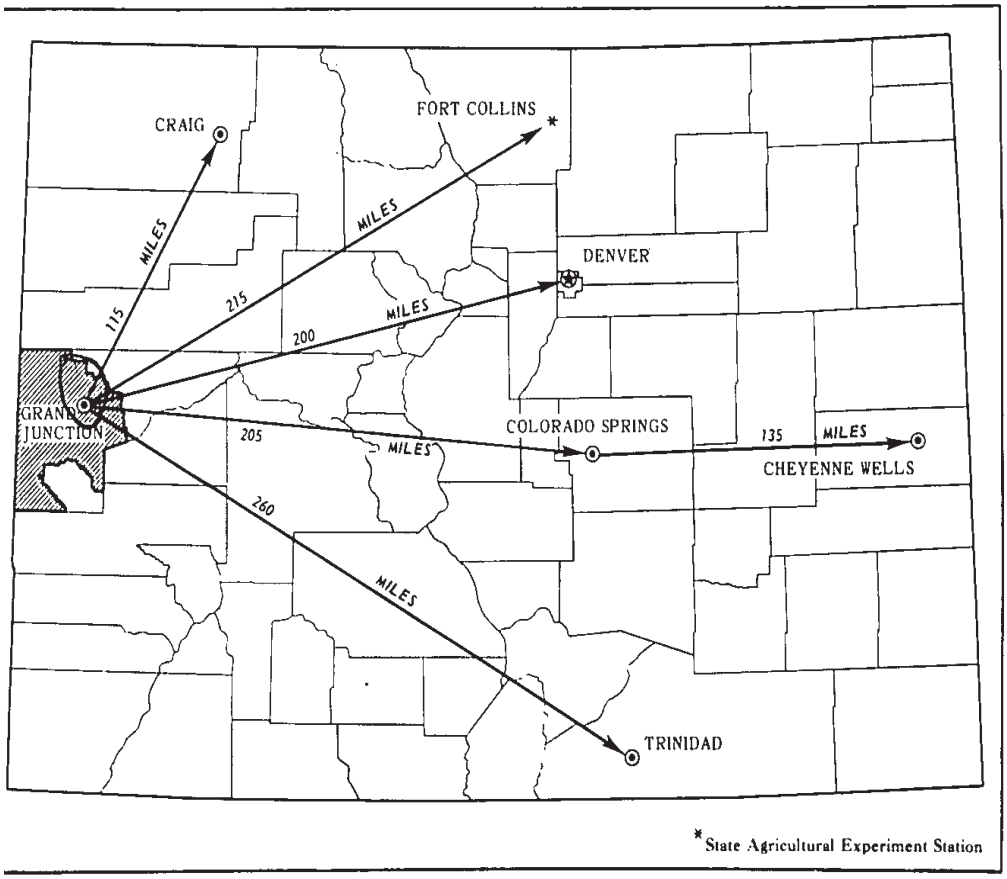
Newcomers in the area may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General Nature of the Area."

Cover: Native range in an area of Mayflower-Skyway soils.

Contents

Issued February 1978

Summary of Tables



Location of Mesa County Area in Colorado.

SOIL SURVEY OF MESA COUNTY AREA, COLORADO

By Clayton F. Spears and Evan V. Kleven, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service, in cooperation with the Colorado Agricultural Experiment Station

THE MESA COUNTY AREA is in the western part of Colorado. It takes in about 1,040,260 acres, or 1,756 square miles. Grand Junction, the county seat, is in the northeastern part of Mesa County, just outside the survey area.

Most of the area is used for range. Raising beef cattle and sheep are the main enterprises. Recreation is of growing importance. A very small part, about 1,000 acres, of the area is used for irrigated crops.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in the Mesa County Area, where they are located, and how they can be used. The soil scientists went into the county knowing they were likely to find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in this survey.

Soils that have a profile almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or geographic feature near the place where a soil of that series was first observed and mapped. Avalon and Glenberg, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Avalon loam is one of several phases within the Avalon series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map that are identified by a common symbol are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Mesa County Area: soil complexes and soil associations.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. An example is Nelman-Lazear sandy loams, 3 to 12 percent slopes.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the dominant soils, joined by a hyphen. Fruita-Avalon association, undulating, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called miscellaneous areas and

are given descriptive names. Gullied land is a miscellaneous area in the Mesa County Area.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the survey area. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It typically consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in an association can occur in other associations, but in different patterns.

A map showing soil associations is useful to people who want to have a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide for broad planning of a watershed, a wooded tract, or a wildlife area or for broad planning of recreation facilities, community developments, and such engineering works as transportation corridors. It is not a suitable map for detailed planning of management for a farm or field or for selecting a site for a road or building or other structure, because the soils within an association ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The seven soil associations in this survey area are described on the pages that follow.

1. *Fruita-Avalon association*

Deep, nearly level to rolling, well-drained loam soils that formed in sediment from sedimentary rocks; on fans, benches, and high terraces

This association is in the northwestern part of the survey area. It consists mainly of benches and fans. The slope is 0 to 12 percent.

This association makes up about 5 percent of the survey area. About 50 percent of the association is made up of Fruita soils, 35 percent is Avalon soils, and the rest is minor soils.

Fruita soils are gently sloping to rolling. They are on benches and fans. In a representative profile the surface layer is brown loam about 5 inches thick. The subsoil is brown clay loam about 9 inches thick. The substratum is pinkish-gray loam about 12 inches thick. It is underlain by pinkish-gray clay loam that extends to a depth of 60 inches or more.

Avalon soils are level or nearly level to rolling. They are on high terraces and ridges. In a representative profile the surface layer is yellowish-brown loam about 6 inches thick. The layer below that is brown loam about 4 inches thick. The next layer is pink or white loam that extends to shale or sandstone at a depth of about 44 inches.

The minor soils in this association are Chipeta, Persayo, and Youngston soils. The Chipeta and Persayo soils are shallow and are underlain by shale. The Youngston soils are deep and are on flood plains.

This soil is used mainly for livestock grazing.

2. *Persayo-Badland-Chipeta association*

Shallow, gently sloping to steep, well-drained silty clay and silt loam soils that formed in residuum from shale and in rolling to very steep badlands; on uplands

This association is mainly north of the Colorado River and west of Grand Junction. The slope is 3 to 60 percent.

This association makes up about 16 percent of the survey area. About 30 percent of the association is made up of Persayo soils, 30 percent is Badland, and 25 percent is Chipeta soils. The rest is minor soils.

Chipeta soils are gently sloping to steep. They are on uplands. In a representative profile the surface layer is light-gray silty clay about 2 inches thick. The underlying layer is very pale brown and gray silty clay about 10 inches thick. It is underlain by slightly weathered marine shale.

Persayo soils are gently sloping to steep. They are on uplands. In a representative profile the surface layer is pale-yellow silt loam about 5 inches thick. The underlying layer is light brownish-gray silt loam that extends to yellowish-brown shale at a depth of about 16 inches.

Badland consists of barren or nearly barren hills and outcrops of gypsiferous marine shales and some clay. The landscape is rough and broken, and it has rolling hills that are separated by many narrow valleys or gullies.

The minor soils in this association are Fruita, Avalon, and Billings soils. Fruita and Avalon soils are deep and are on fans and benches and high terraces. Billings soils are deep and are on flood plains and terraces.

This association is used mainly for livestock grazing.

3. *Utaline-Nelman-Lazear association*

Deep to shallow, gently sloping to steep, well-drained stony loam, sandy loam, and gravelly loam soils that formed in materials weathered from basalt and sandstone; on high terraces, upland hills, and ridges

This association is mainly in the area southeast of Grand Junction. The slope is 3 to 30 percent.

This association makes up about 5 percent of the survey area. About 30 percent of the association is Utaline soils, 30 percent is Nelman soils, and 25 percent is Lazear soils. The rest is minor soils.

Utaline soils are deep and gently sloping to steep. They are on high terraces and terrace edges. In a representative profile the surface layer is pink stony loam about 4 inches thick. The underlying layer is pink, pinkish-white, and pinkish-gray very cobbly loam that extends to a depth of 60 inches or more.

Nelman soils are moderately deep over sandstone and gently sloping to rolling. They are on upland hills and ridges. In a representative profile the surface layer is pinkish-gray sandy loam about 6 inches thick. The underlying layer is light-brown or pink fine sandy loam about 20 inches thick to hard sandstone bedrock.

Lazear soils are shallow over hard sandstone and gently sloping to steep. They are on hillcrests and ridges. In a representative profile, the surface layer is light brownish-gray gravelly loam about 4 inches thick. The underlying layer is light-brown gravelly loam over hard sandstone bedrock at a depth of about 14 inches.

The minor soils in this association are Avalon and Blackston soils. These are deep soils on terraces. Also included in this association are small areas of Rock outcrop and Shale outcrop.

This association is used mainly for livestock grazing.

4. *Rock outcrop-Palma-Potts association*

Steep and very steep rock outcrop, and gently sloping to rolling, deep, well-drained sandy loam soils that formed in aeolian deposits; on uplands

This association is in the southern and central parts of the survey area. Rock outcrop is on very steep terrain, cliffs, and steep mesa edges. Palma and Potts soils are on upland hills and ridges. They have a slope of 3 to 12 percent.

This association makes up about 57 percent of the survey area. About 60 percent of the association is made up of Rock outcrop, 20 percent is Palma soils, and 10 percent is Potts soils. The rest is minor soils.

Included in mapping with the areas of Rock outcrop are areas of stony slopes and slides and small areas of shallow and very shallow, steep soils.

Palma soils are gently sloping to rolling. They are on upland hills and ridges. In a representative profile the surface layer is reddish-brown sandy loam about 4 inches thick. The subsoil is reddish-brown or light reddish-brown fine sandy loam about 24 inches thick. It is underlain by pink or yellowish-red sandy loam that extends to a depth of 60 inches or more.

Potts soils are deep and gently sloping to rolling. They are on upland hills and ridges. In a representative profile the surface layer is reddish-brown sandy loam about 4 inches thick. The subsoil is reddish-brown loam or clay loam and light-reddish brown loam about 20 inches thick. The substratum is light reddish-brown loam that extends to a depth of 60 inches or more.

The minor soils in this association are Batterson, Loma, and Dominguez soils. Batterson soils are shallow and on upland hills and ridges. Loma soils are deep and on mesas. Dominguez soils are deep and on alluvial fans.

This association is used mainly for livestock grazing. A few small areas are irrigated.

5. *Owen Creek-Miracle association*

Moderately deep, gently sloping to steep, well-drained fine sandy loam soils that formed in residuum from sandstone and shale; on mountain slopes, ridges, and mesas

This association is in the west-central and southwestern parts of the survey area. The slope is 3 to 30 percent.

This association makes up about 5 percent of the survey area. About 50 percent of the association is made up of Owen Creek soils, and 40 percent is Miracle soils. The rest is minor soils.

Owen Creek soils are moderately deep and gently sloping to steep. They are on mountain slopes, ridges, and small benches. In a representative profile the surface layer is dark grayish-brown fine sandy loam about 15 inches thick. The subsoil is brown sandy clay loam about 6 inches thick. The substratum is brown heavy clay loam about 9 inches thick over sandy shale and sandstone bedrock.

Miracle soils are moderately deep and gently sloping to rolling. They are on upland hills and mesas. In a representative profile the surface layer is brown fine sandy loam about 4 inches thick. The subsoil is brown or reddish-brown sandy clay loam about 26 inches thick. It is underlain by hard reddish-brown sandstone.

The minor soils in this association are Mayflower and Skyway soils and Rock outcrop. Mayflower and Skyway soils are moderately deep and are underlain by sandstone and shale.

This association is used mainly for livestock grazing.

6. *Mayflower-Cebone-Bangston association*

Deep and moderately deep, gently sloping to steep, well-drained silt loam, loam, and sandy loam soils that formed in sediments weathered from sandstone and shale; on mountain slopes and ridges

This association is in the west-central part of the survey area. It consists of mountain slopes, ridges, and benches. The slope is 5 to 40 percent.

This association makes up about 10 percent of the survey area. About 35 percent of the association is made up of Mayflower soils, 25 percent is Cebone soils, and 25 percent is Bangston soils. The rest is minor soils.

Mayflower soils are moderately deep and gently sloping to steep. They are on mountain slopes and ridges. In a representative profile the surface layer is dark-gray silt loam about 8 inches thick. The subsoil is reddish-gray and reddish-brown silty clay that extends to interbedded shale and sandstone at a depth of about 32 inches.

Cebone soils are moderately deep and gently sloping to steep. They are on mountain slopes, ridges, and benches. In a representative profile the surface layer is a dark grayish-brown loam about 13 inches thick. The subsurface is pinkish-gray fine sandy loam about 11 inches thick. The subsoil is reddish-brown and brown

clay about 14 inches thick. It is underlain by noncalcareous shale and sandstone.

Bangston soils are deep and gently sloping to steep. They are on upland hills and ridges. In a representative profile the surface layer is under a thin mat of decomposed organic material and is dark grayish-brown sandy loam about 9 inches thick. The underlying material is brown loamy sand that extends to a depth of 60 inches or more.

The minor soils in this association are Gateway and Skyway soils. Both soils are moderately deep and are underlain by sandstone and shale.

Mayflower soils are used mainly for livestock grazing. Cebone and Bangston soils are used for grazing and timber production.

7. *Ildefonso-Scholle-Stony land association*

Deep, gently sloping to rolling, well-drained cobbly sandy loam and stony loam soils that formed in sediments from mixed rocks and in moderately steep or steep stony land; on fans and upland slopes

This association is in the eastern part of the survey area. It consists mainly of fans and mountain slopes. The slope is 3 to 60 percent.

This association makes up about 2 percent of the survey area. About 30 percent of the association is made up of Ildefonso soils, 30 percent is Scholle soils, and 30 percent is Stony land. The rest is minor soils.

Ildefonso soils are gently sloping to rolling. They are on fans. In a representative profile the surface layer is brown cobbly sandy loam about 5 inches thick. The underlying layers are light-brown cobbly sandy loam and pinkish-white very cobbly sandy loam that extend to a depth of 60 inches or more.

Scholle soils are gently sloping to rolling. They are on fans and upland slopes. In a representative profile the surface layer is brown stony loam about 5 inches thick. The subsoil is brown stony silty clay loam about 7 inches thick. The substratum is pinkish-white stony loam that extends to a depth of 40 inches or more.

Stony land is on moderately steep or steep fans and mountain slopes. It consists of cobbles, boulders, and stones that are 10 to 200 feet thick or more.

The minor soils in this association are Utaline and Persayo soils. Utaline soils are deep and stony. Persayo soils are shallow over shale.

This association is used for livestock grazing and by wildlife.

Descriptions of the Soils

This section describes the soil series and mapping units in the Mesa County Area. Each soil series is described in detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit. Color terms are for dry soil unless otherwise stated.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Rock land and Rock outcrop, for example, do not belong to a soil series, but nevertheless, are listed in alphabetic order along with the soil series.

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and range site in which the mapping unit has been placed. The page for the description of each capability unit and range site can be learned by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*6*).[1]

Alluvial Land

Ad—Alluvial land. This mapping unit consists of very gravelly or cobbly sandy alluvium on flood plains that are nearly level. The areas are crisscrossed by meandering and braided stream channels. Most areas are subject to flooding one to several times a year. The vegetation is sparse and is mostly cottonwood, willow, sagebrush, rabbitbrush, grasses, and weeds.

These areas are used mainly by wildlife. They are valuable as a source of sand and gravel. Capability unit VIIIw–1; not placed in a range site.

Avalon Series

The Avalon series consists of deep, well-drained soils. These soils formed in sediment from sedimentary rocks on high terraces. The slope is 0 to 12 percent, and elevation is 4,900 to 5,400 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 9 inches. The mean annual temperature is 54° F., and the frost-free season is 165 to 175 days.

In a representative profile the surface layer is yellowish-brown loam about 6 inches thick. The underlying layer is brown loam about 4 inches thick. It in turn is underlain by pink or white loam to a depth of about 44 inches. Shale or sandstone is below that depth.

Avalon soils have moderate permeability and a mod-

[1] Italic numbers in parentheses refer to Literature Cited, p. 55.

TABLE 1.—*Acreage and extent of the soils*

Soil	Approximate area	Proportionate extent
	Acres	*Percent*
Alluvial land	2,440	0.2
Avalon loam, 0 to 3 percent slopes	1,640	.2
Avalon loam, 3 to 12 percent slopes	13,360	1.3
Badland	93,880	9.0
Bankard loamy sand	4,440	.4
Batterson-Rock outcrop complex, 3 to 12 percent slopes	49,800	4.8
Billings silty clay loam	19,320	1.8
Blackston stony loam, 3 to 25 percent slopes	3,640	.3
Chipeta silty clay, 3 to 25 percent slopes	8,960	.9
Dominguez clay loam, 3 to 12 percent slopes	2,000	.2
Dwyer loamy sand, 3 to 12 percent slopes	14,400	1.4
Fruita-Avalon association, undulating	15,240	1.5
Gateway-Cebone-Bangston association, steep	33,880	3.2
Gateway-Cebone-Bangston association, very steep	9,640	.9
Gibbler-Witt association, undulating	3,080	.3
Glenberg sandy loam, 0 to 3 percent slopes	9,040	.9
Glenberg sandy loam, 3 to 8 percent slopes	8,560	.8
Gullied land	1,920	.2
Ildefonso cobbly sandy loam, 3 to 12 percent slopes	3,720	.4
Lazear-Rock outcrop complex, 3 to 30 percent slopes	10,160	1.0
Loma loam	3,720	.4
Mayflower-Skyway association, rolling	21,280	2.0
Miracle-Splitro association, undulating	28,400	2.7
Nelman sandy loam, 3 to 12 percent slopes	6,240	.6
Nelman-Lazear sandy loams, 3 to 12 percent slopes	3,200	.3
Owen Creek-Miracle complex, 3 to 12 percent slopes	17,880	1.7
Owen Creek-Miracle complex, 12 to 30 percent slopes	3,280	.3
Palma sandy loam, 3 to 12 percent slopes	19,720	1.9
Persayo silt loam, 3 to 25 percent slopes	46,200	4.2
Potts sandy loam, 3 to 12 percent slopes	26,040	2.5
Rock land	116,310	12.0
Rock outcrop	368,460	35.0
Scholle stony loam, 3 to 12 percent slopes	1,120	.1
Stony land	20,250	2.0
Uffens loam, 3 to 12 percent slopes	3,560	.3
Unaweep sandy loam, 3 to 12 percent slopes	5,000	.5
Utaline stony loam, 3 to 25 percent slopes	19,960	1.9
Utaline-Shale outcrop complex	8,400	.8
Wet alluvial land	840	.1
Youngston loam	11,280	1.0
Total	1,040,260	100.0

erate available water capacity. They are moderately alkaline. Roots can penetrate to a depth of 40 to 60 inches.

These soils are used for grazing, as wildlife habitat, and for recreation.

Representative profile of Avalon loam, 3 to 12 percent slopes, NE¼ sec. 25, T. 8 S., R. 102 N.

A11—0 to 6 inches, yellowish-brown (10YR 5/4) loam, dark yellowish brown (10YR 4/4) when moist; weak, platy parting to weak, fine, granular structure; soft, friable; calcareous; moderately alkaline; clear, smooth boundary.

AC—6 to 10 inches, light-brown (7.5YR 6/3) loam, dark brown (7.5YR 4/4) when moist; weak, moderate, subangular blocky parting to weak, fine, subangular blocky structure; slightly hard, friable; calcareous; moderately alkaline; gradual, smooth boundary.

C1ca—10 to 26 inches, pink (7.5YR 7/4) loam, brown (7.5YR 5/4) when moist; massive; slightly hard, friable; calcareous; moderately alkaline; gradual, smooth boundary.

C3—26 to 44 inches, white (10YR 8/2) loam, light brownish gray (10YR 6/2) when moist; massive; hard, very friable; calcareous; moderately alkaline; about 15 percent gravel.

IIC4—44 to 54 inches, weathered shale.

The A horizon is a very fine sandy loam or loam. The C horizon is gravelly loam or loam. Flakes, seams, and nodules of calcium carbonate are in the Ca horizon.

AvA—Avalon loam, 0 to 3 percent slopes. This soil is nearly level and is on high terraces.

Included with this soil in mapping are a few small areas of Blackston soils.

Runoff is slow. The hazard of water erosion is slight.

This soil is used mainly for grazing and recreation. Capability unit VIe–1; Loamy Salt Desert range site.

AvC—Avalon loam, 3 to 12 percent slopes. This soil is gently sloping to rolling and is on high terraces and ridges. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Fruita and Persayo soils.

Runoff is moderate. The hazard of erosion is moderate.

This soil is used mainly for grazing and as wildlife habitat. Capability unit VIe–1; Loamy Salt Desert range site.

Badland

Ba—Badland. This mapping unit consists of a rough and broken succession of rolling to very steep, nearly barren hills and ridges separated by steep-walled, deeply entrenched gullies and canyons. Badland consists of gypsiferous shale that contains layers of sandstone outcrop along canyon walls. It produces a large amount of sediment.

Included with this unit in mapping are Chipeta and Persayo soils. These soils make up about 10 percent of the mapped area.

Vegetation on the included soils is mainly saltbush, sparse pinyon and juniper, and some grass.

Badland is used mainly as refuge areas for wildlife and as scenic areas. Capability unit VIIIe–1; not placed in a range site.

Bangston Series

The Bangston series consists of deep, well-drained soils. These soils formed in sediment weathered from sandstone on upland hills and ridges. The slope is 2 to 60 percent, and elevation is 8,000 to 8,500 feet. The natural vegetation is mainly spruce, fir, aspen, and grasses of the Subalpine zone. The average annual precipitation is 20 inches. The mean annual temperature is 38° F., and the frost-free season is 35 to 50 days.

In a representative profile the surface layer is under a thin mat of decomposed organic material and is dark grayish-brown sandy loam about 9 inches thick. The

underlying material is brown loamy sand that extends to a depth of 60 inches or more.

Bangston soils have rapid permeability and a low available water capacity. They are neutral. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, timber, and as wildlife habitat.

Representative profile of Bangston sandy loam, in an area of Gateway-Cebone-Bangston association, NE¼ sec. 29, T. 13 S., R. 101 W., in an area of timber.

O2—1 inch to 0, partly decomposed organic material, principally from leaves, needles, and grass.
A11—0 to 9 inches, dark grayish-brown (10YR 4/2) light sandy loam, very dark brown (10YR 2/2) when moist; weak, fine, crumb structure; soft, very friable; neutral; clear, smooth boundary.
A12—9 to 30 inches, brown (10YR 4/3) loamy sand, dark brown (10YR 3/3) when moist; single grained; soft, very friable; neutral; gradual, smooth boundary.
C—30 to 60 inches, brown (10YR 5/3) loamy sand, dark brown (10YR 4/3) when moist; single grained; soft, very friable; about 5 percent small fragments of sandstone; neutral.

The A horizon is sandy loam or heavy loamy sand. Fragments of sandstone make up as much as 15 percent of the C horizon. Bangston soils are mapped in this survey only as part of the Gateway-Cebone-Bangston association.

Bankard Series

The Bankard series consists of deep, well-drained soils. These soils formed in sandy alluvium on flood plains. The slope is 1 to 5 percent, and elevation is 4,900 to 5,200 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and annual weeds. The average annual precipitation is 10 inches. The mean annual temperature is 52° F., and the frost-free season is 165 to 175 days.

In a representative profile the surface layer is pale-brown loamy sand about 5 inches thick. The underlying layers are pale-brown or very pale brown loamy sand and fine sand.

Bankard soils have rapid permeability and a low available water capacity. They are moderately alkaline. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, as wildlife habitat, and for recreation.

Representative profile of Bankard loamy sand, SE¼ sec. 21, T. 8 S., R. 103 W.

A1—0 to 6 inches, pale-brown (10YR 6/3) loamy sand, brown (10YR 5/3) when moist; massive; slightly hard, very friable; calcareous; moderately alkaline; clear, wavy boundary.
C1—6 to 14 inches, pale-brown (10YR 6/3) fine sand, brown (10YR 5/3) when moist; single grained; soft, very friable; calcareous; moderately alkaline; clear, smooth boundary.
C2—14 to 26 inches, pale-brown (10YR 6/3) fine sand, dark brown (10YR 4/3) when moist; single grained; soft, very friable; calcareous; moderately alkaline; clear, smooth boundary.
C3—26 to 33 inches, pale-brown (10YR 6/3) loamy sand, dark brown (10YR 4/3) when moist; weak, fine subangular blocky structure; slightly hard, very friable; calcareous; moderately alkaline; clear, smooth boundary.
C4—33 to 64 inches, very pale brown (10YR 7/3) loamy sand, brown (10YR 5/3) when moist; massive; soft, very friable; calcareous; moderately alkaline.

The A horizon is fine sand or loamy sand.

Bd—Bankard loamy sand. This soil is nearly level to gently sloping and is on flood plains and low terraces. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Youngston soils.

Runoff is slow, and the hazards of soil blowing and water erosion are moderate to high. Gullies 4 to 6 feet deep are common. The soil is subject to flooding.

This soil is used mainly for grazing and as wildlife habitat. Capability unit VIIw–1; Salt Flats range site.

Batterson Series

The Batterson series consists of shallow, well-drained soils. These soils formed in residuum from sandstone on upland hills and ridges. The slope is 3 to 12 percent, and elevation is 6,000 to 7,500 feet. The natural vegetation is mainly pinyon, juniper, and Indian ricegrass and wheatgrass mixed with shrubs and forbs. The average annual precipitation is 14 inches. The mean annual temperature is 48° F., and the frost-free season is 110 to 125 days.

In a representative profile the surface layer is reddish-brown loamy sand about 4 inches thick. The underlying layers are reddish-brown and yellowish-red loamy sand; they in turn are underlain by hard reddish-brown sandstone at a depth of about 15 inches.

Batterson soils have rapid permeability and a low available water capacity. They are moderately alkaline. Roots can penetrate to a depth of 10 to 20 inches.

These soils are used for grazing, as wildlife habitat, and for watershed areas.

Representative profile of Batterson loamy sand, in an area of Batterson-Rock outcrop complex, 3 to 12 percent slopes, SW¼ sec. 19, T. 12 S., R. 102 W., in an area of grass.

A1—0 to 4 inches, reddish-brown (5YR 5/3) loamy sand, reddish-brown (5YR 4/3) when moist; weak, fine granular structure; soft, very friable; 10 percent is small fragments of sandstone; calcareous; moderately alkaline; gradual, smooth boundary.
AC—4 to 7 inches, reddish-brown (5YR 5/4) loamy sand that contains lenses of sandy loam, reddish brown (5YR 4/4) when moist; single grained; loose; 10 percent is small fragments of sandstone; calcareous; moderately alkaline; clear, smooth boundary.
C—7 to 15 inches, yellowish-red (5YR 5/6) loamy sand that contains lenses of sandy loam, yellowish red (5YR 4/6) when moist; single grained; loose; 20 percent is small fragments of sandstone; calcareous; moderately alkaline; abrupt, smooth boundary.
R—15 inches, reddish-brown calcareous sandstone.

The depth to sandstone is 10 to 20 inches. Fragments of sandstone make up 10 to 30 percent of the C horizon. In some profiles, soft lime has accumulated in the C horizon.

BrC—Batterson-Rock outcrop complex, 3 to 12 percent slopes. This complex is made up of shallow, gently sloping to rolling soils and areas of Rock outcrop on upland hills and ridges and along drainageways. It consists of about 60 percent Batterson loamy sand and 35 percent Rock outcrop. The Batterson soil has the profile described as representative of the series.

Included with this complex in mapping are Palma and Dwyer soils.

Runoff is medium. The hazard of erosion is moderate or high.

Pinyon and juniper trees are harvested for posts and firewood. Some areas of this complex are used for grazing. Capability unit VIIe–1; not placed in a range site.

Billings Series

The Billings series consists of deep, well-drained soils. These soils formed in alluvium on flood plains and low terraces. The slope is 0 to 3 percent, and elevation is 4,700 to 5,200 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 10 inches. The mean annual temperature is 54° F., and the frost-free season is 165 to 175 days.

In a representative profile the surface layer is light brownish-gray silty clay loam about 3 inches thick. The underlying layers are brownish-gray silty clay loam that extend to a depth of 60 inches or more.

Billings soils have slow permeability and a high available water capacity. They are moderately alkaline. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, irrigated crops, and as wildlife habitat.

Representative profile of Billings silty clay loam, SE¼ sec. 27, T. 9 S., R. 104 W.

A1—0 to 3 inches, light brownish-gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) when moist; weak, thin, platy parting to weak, fine, granular structure; slightly hard, friable; moderately alkaline; clear, smooth boundary.

C1—3 to 12 inches, light brownish-gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) when moist; weak, medium, subangular blocky parting to weak, fine, subangular blocky structure; slightly hard, friable; strongly calcareous; moderately alkaline; gradual, wavy boundary.

C2—12 to 60 inches, light brownish-gray (10YR 6/2) silty clay loam; massive; hard, friable; strongly calcareous; moderately alkaline; seams and nodules of gypsum mostly in the lower 25 inches; several layers, about 1 inch thick of light brownish-gray (10YR 6/2) silty clay in lowermost 30 inches.

The A horizon is silty clay loam or silty clay. It is mildly alkaline or moderately alkaline.

Bs—Billings silty clay loam. This soil is nearly level and is on flood plains and low terraces. The slope is 0 to 3 percent. It has the profile described as representative of the series.

Included with this soil in mapping are areas of Youngston and Persayo soils. These soils make up about 10 percent of the mapped area.

Runoff is moderate, and the hazard of erosion is moderate. Deep gullies are common throughout most mapped areas of this soil. Gullies limit the beneficial effect of overflow and restrict use by man and animals.

The soil is used mostly as range. Small areas in the Kannah Creek and Whitewater Creek areas are used for irrigated corn, alfalfa, and pasture. Capability unit IIs–1 (irrigated), VIIs–2 (nonirrigated); Salt Flats range site.

Blackston Series

The Blackston series consists of deep, well-drained soils. These soils formed in sediment weathered from basalt on high terraces. The slope is 3 to 25 percent, and elevation is 4,800 to 5,500 feet. The natural vegetation is mainly saltbush, shadscale, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 9 inches. The mean annual temperature is 51° F., and the frost-free season is 160 to 175 days.

In a representative profile the surface layer is pinkish-gray gravelly loam about 5 inches thick. The underlying layers are pinkish-white gravelly loam and very gravelly loam; these extend to a depth of about 28 inches. Below these layers are sand, gravel, and cobblestones that extend to a depth of 60 inches or more.

Blackston soils have moderate permeability above a depth of 28 inches and rapid permeability below that depth. They have a low available water capacity, and they are moderately alkaline. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Blackston stony loam, 3 to 25 percent slopes, SE¼ sec. 15, T. 2 S., R. 1 E., in an area of grass.

A1—0 to 5 inches, pinkish-gray (7.5YR 6/2) gravelly loam, brown (7.5YR 5/3) when moist; moderate, fine, granular structure, but weak, platy in the upper inch; soft, very friable; common dark mineral grains; 15 percent fragments of basalt, pebbles, and cobbles; calcareous; moderately alkaline; clear, wavy boundary.

C1ca—5 to 14 inches, pinkish-white (7.5YR 8/2) gravelly loam, light brown (7.5YR 6/3) when moist; massive; hard, very friable; common dark mineral grains; 40 percent basalt gravel; much, visible, finely divided secondary calcium carbonate; calcium carbonate equivalent about 25 percent; moderately alkaline; gradual, wavy boundary.

C2cam—14 to 28 inches, pinkish-white (7.5YR 8/2) very gravelly loam, light brown (7.5YR 6/3) when moist; massive; very hard, firm; some thin discontinuous lenses of weakly lime-cemented material; common dark mineral grains; 60 to 70 percent basalt gravel; visible secondary calcium carbonate, mostly finely divided; calcium carbonate equivalent about 30 percent; moderately alkaline; gradual, wavy boundary.

IIC3ca—28 to 60 inches, sand, gravel, and cobbles that have coarse fragments which are mostly basalt; common dark mineral grains; calcareous, some accumulated secondary calcium carbonate on underside of sand grains and pebbles; moderately alkaline.

The A1 horizon is gravelly sandy loam or gravelly loam.

BtD—Blackston stony loam, 3 to 25 percent slopes. This soil is gently sloping to steep and is on high terraces and benches. It has the profile described as representative of the series.

Included with this soil in mapping are areas of Utaline and Avalon soils; these make up as much as 10 percent of the mapped area. Also included in some places are small areas of soils, along terrace edges, that have shale or sandstone bedrock at a depth of about 36 inches.

Runoff is moderate to rapid. The hazard of erosion is moderate.

This soil is used mostly for grazing and as a source of gravel. Gravel pits and borrow areas are common. Capability unit VIe–1; Loamy Salt Desert range site.

Cebone Series

The Cebone series consists of moderately deep, well-

drained soils. These soils formed in sediment weathered from shale and sandstone on mountain slopes and ridges. The slope is 2 to 60 percent, and elevation is 8,000 to 9,500 feet. The natural vegetation is mainly spruce, fir, or aspen and grasses of the subalpine zone. The average annual precipitation is 20 inches. The mean annual temperature is 40° F., and the frost-free season is 35 to 50 days.

In a representative profile the surface layer is dark grayish-brown loam about 13 inches thick. The subsurface is pinkish-gray fine sandy loam about 11 inches thick. The subsoil is reddish-brown and brown clay about 14 inches thick. It is underlain by noncalcareous shale and sandstone.

Cebone soils have slow permeability and a low or moderate available water capacity. They are neutral. Roots can penetrate to a depth of 38 to 40 inches.

These soils are used for timber, grazing, and watershed.

Representative profile of Cebone loam, in an area of Gateway-Cebone-Bangston association, NW¼ sec. 7, T. 14 S., R. 10 W., in an area of timber.

A1—0 to 13 inches, dark grayish-brown (10YR 4/2) loam, very dark brown (10YR 2/2) when moist; strong, fine, crumb and granular structure; soft, very friable; neutral; clear, smooth boundary.

A2—13 to 24 inches, pinkish-gray (7.5YR 7/2) fine sandy loam, brown (7.5YR 5/4) when moist; moderate, thick platy parting to moderate, fine, granular structure; soft, very friable; neutral; a few seams and nodules of more clayey material in the lower part; gradual, wavy boundary.

B2t—24 to 38 inches, reddish-brown (5YR 5/4) and brown (7.5YR 5/4) clay, reddish brown (5YR 4/4) and brown or dark brown (7.5YR 4/4) when moist, brown (7.5YR 5/4) when crushed, and brown or dark brown (7.5YR 4/4) when crushed and moist; moderate, coarse, subangular blocky structure; hard, very friable; thick, continuous, clay films on faces of peds and in root channels; neutral; gradual, wavy boundary.

C—38 inches, noncalcareous shale and sandstone.

The A1 horizon is very fine sandy loam or loam. Depth to shale or sandstone bedrock ranges from 20 to 40 inches.

Cebone soils in this survey are mapped only in associations with Gateway and Bangston soils.

Chipeta Series

The Chipeta series consists of shallow, well-drained soils. These soils formed in material weathered from shale on uplands. The slope is 3 to 25 percent, and elevation is 4,800 to 5,200 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 9 inches. The mean annual temperature is 52° F., and the frost-free season is 165 to 175 days.

In a representative profile the surface layer is light-gray silty clay about 2 inches thick. The underlying layer is very pale brown and gray silty clay about 10 inches thick. It is underlain by slightly weathered marine shale.

Chipeta soils have slow permeability and a low available water capacity. They are moderately alkaline. Roots can penetrate to a depth of 12 to 17 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Chipeta silty clay, 3 to 25 percent slopes, SE¼ sec. 23, T. 9 S., R. 104 W.

A1—0 to 2 inches, light-gray (10YR 7/2) silty clay, light brownish gray (10YR 6/2) when moist; weak, very fine, granular structure; hard, friable; calcareous; moderately alkaline; clear, wavy boundary.

C1ca—2 to 12 inches, very pale brown (10YR 7/3) and gray (10YR 6/1) silty clay, pale brown (10YR 6/3) when moist; weak, fine, subangular blocky structure; hard, firm; calcareous; moderately alkaline; clear, wavy boundary.

C2—12 to 26 inches, weathered Mancos shale.

The A1 horizon is silty clay loam or silty clay. Depth to shale ranges from 10 to 15 inches.

ChD—Chipeta silty clay, 3 to 25 percent slopes. This soil is gently sloping to steep and is on uplands. It has the profile described as representative of the series.

Included with this soil in mapping are areas of Persayo soils that make up about 10 percent of the mapped area and small areas of Badland. Also included are a few areas of a soil that has a surface layer of silt loam.

Runoff is moderate to rapid. The hazard of erosion is high.

The soil is used mainly for grazing. Capability unit VIIe–1; Clayey Salt Desert range site.

Dominguez Series

The Dominguez series consists of deep, well-drained soils. These soils formed in sediment weathered from calcareous shale. The slope is 3 to 12 percent, and elevation is 6,000 to 7,400 feet. The natural vegetation is mainly sagebrush, rabbitbrush, wheatgrass, and bluegrass. The average annual precipitation is 15 inches. The mean annual temperature is 50° F., and the frost-free season is 100 to 125 days.

In a representative profile the surface layer is brown heavy clay loam about 5 inches thick. The subsoil is reddish-brown heavy clay loam or clay about 20 inches thick. The substratum is reddish-brown clay about 22 inches thick.

Dominguez soils have slow permeability and a high available water capacity. They are moderately alkaline. Roots can penetrate to a depth of about 40 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Dominguez clay loam, 3 to 12 percent slopes, NW¼ sec. 20, T. 11 S., R. 102 W., in an area of grass.

A1—0 to 5 inches, brown (7.5YR 5/3) heavy clay loam, dark-brown (7.5YR 4/3) when moist; moderate, fine, granular structure; soft, very friable; calcareous; moderately alkaline; clear, smooth boundary.

B21—5 to 9 inches, reddish-brown (5YR 5/3) heavy clay loam, reddish brown (5YR 4/3) when moist; weak, coarse, prismatic parting to moderate, medium, blocky structure; hard and extremely hard, very friable; ¼-inch to ½-inch cracks, when dry; few films of clay on vertical faces of peds; calcareous; moderately alkaline; clear, smooth boundary.

B22—9 to 25 inches, reddish-brown (5YR 5/3) clay, reddish brown (5YR 4/3) when moist; moderate, very coarse, prismatic parting to moderate, coarse, angular blocky structure; extremely hard, very plastic; few films of clay on vertical faces of peds; ½-inch to 1-inch cracks, when dry; many slickensides; calcareous; moderately alkaline; gradual, wavy boundary.

C1ca—25 to 35 inches, reddish-brown (5YR 5/3) clay, red-

dish brown (5YR 4/3) when moist; weak, very coarse, angular blocky structure; extremely hard, very plastic; ½-inch to 1-inch cracks, when dry; some visible concretions, thin seams, and streaks of secondary calcium carbonate; moderately alkaline; gradual, wavy boundary.

C2ca—35 to 47 inches, light reddish-brown (5YR 6/3) clay, reddish brown (5YR 4/3) when moist; weak, very coarse, angular blocky structure; extremely hard, very plastic; ½-inch to 1-inch cracks when dry; some visible concretions, thin seams, and streaks of secondary calcium carbonate; moderately alkaline.

DoC—Dominguez clay loam, 3 to 12 percent slopes. This soil is gently sloping to rolling and is on alluvial fans. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Potts soils.

Runoff is moderate. The hazard of water erosion is high, and the hazard of soil blowing is slight.

This soil is used mostly for grazing and as wildlife habitat. Capability unit VIe–2; Clayey Foothills range site.

Dwyer Series

The Dwyer series consists of deep, excessively drained soils. These soils formed in aeolian sands on mesas and benches. The slope is 3 to 12 percent, and elevation is 6,000 to 7,400 feet. The natural vegetation is mainly big sagebrush, Indian ricegrass, bluegrass, and a few pinyon and juniper. The average annual precipitation is 16 inches. The mean annual temperature is 50° F., and the frost-free season is 100 to 125 days.

In a representative profile the surface layer is pinkish-gray loamy sand about 4 inches thick. The underlying layers are reddish-brown loamy sand and brown loamy fine sand that extend to a depth of 60 inches or more.

Dwyer soils have very rapid permeability and a low or moderate available water capacity. They are mildly alkaline in the upper 22 inches and moderately alkaline in the lowermost 38 inches. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Dwyer loamy sand, 3 to 12 percent slopes, sec. 36, T. 11 S., R. 102 W., in an area of grass.

A1—0 to 4 inches, pinkish-gray (7.5YR 6/2) loamy sand, dark brown (7.5YR 4/2) when moist; single grained; loose, very friable; mildly alkaline; clear, smooth boundary.

C1—4 to 22 inches, reddish-brown (7.5YR 5/4) loamy sand, dark brown (7.5YR 4/4) when moist; single grained; soft, very friable; mildly alkaline; gradual, smooth boundary.

C2—22 to 60 inches, brown (7.5YR 5/4) loamy fine sand, dark brown (7.5YR 4/4) when moist; single grained; slightly hard, very friable; calcareous; moderately alkaline.

The A1 horizon is typically 4 inches thick but ranges from 3 to 7 inches in thickness. Depth to lime ranges from 18 to 36 inches.

DwC—Dwyer loamy sand, 3 to 12 percent slopes. This soil is gently sloping to rolling and is on terraces and mesas. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Palma soils and minor areas of Rock outcrop.

Runoff is slow. The hazard of soil blowing is high, and the hazard of water erosion is slight.

This soil is used mostly for grazing and as wildlife habitat. (fig. 1). Capability unit VIe–2; Sandy Foothills range site.

Fruita Series

The Fruita series consists of deep, well-drained soils. These soils formed in sediment that weathered from sedimentary rock. They are on fans and benches. The slope is 3 to 8 percent, and elevation is 4,800 to 5,400 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 9 inches. The mean annual temperature is 53° F., and the frost-free season is 150 to 175 days.

In a representative profile the surface layer is brown loam about 5 inches thick. The subsoil is brown clay loam about 9 inches thick. The substratum is pinkish-gray loam about 12 inches thick. It is underlain by pinkish-gray clay loam that extends to a depth of 60 inches.

Fruita soils have moderate permeability and a high available water capacity. They are mildly alkaline in the surface layer and in the upper part of the subsoil; below that they are moderately alkaline. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, crops, and as wildlife habitat.

Representative profile of Fruita loam, in an area of Fruita-Avalon association, undulating, SW¼ sec. 32, T. 8 S., R. 102 W., in an area of grass.

A1—0 to 5 inches, brown (10YR 5/3) loam, dark brown (10YR 4/3) when moist; weak, thin, platy breaking to weak, fine, granular structure; slightly hard, very friable; mildly alkaline; clear, smooth boundary.

B2t—5 to 14 inches, brown (7.5YR 5/4) clay loam, reddish brown (5YR 4/4) moist; weak, fine, prismatic parting to moderate, fine, subangular blocky structure; hard, friable; calcareous in the lower part; thin patchy films of clay; mildly alkaline; gradual, smooth boundary.

C1ca—14 to 26 inches, pinkish-gray (7.5YR 6/2) loam, brown (7.5YR 5/4) when moist; massive; hard, slightly sticky; calcareous; moderately alkaline; 50 percent pinkish-white (7.5YR 8/2) nodules of lime; clear, wavy boundary.

C2ca—26 to 60 inches, pinkish-gray (7.5YR 6/2) clay loam, brown (7.5YR 5/4) when moist; massive; hard, sticky; calcareous; moderately alkaline; 10 to 30 percent pinkish-white (7.5YR 8/2) nodules of lime; 20 percent sandstone chips, coarse gravel, and cobbles that increase with depth.

The A horizon is sandy loam or loam. The B2t horizon is loam or clay loam. Coarse fragments make up as much as 20 percent, by volume, of the soil.

FaC—Fruita-Avalon association, undulating. This association consists of about 50 percent Fruita loam and 35 percent Avalon loam. The Fruita soil has the profile described as representative of the series. Fruita soils are on fans and benches that have a slope of 3 to 8

Figure 1.—**Typical landscape in an area of Dwyer loamy sand, 3 to 12 percent slopes.**

percent. Avalon soils are on bench edges and ridgetops that have a slope of 6 to 12 percent.

Included with this association in mapping are Chipeta and Persayo soils. Also included is a soil that is similar to Fruita soil, but it has a subsoil of heavy clay loam or clay.

Runoff is moderate, and the hazard of erosion is moderate to high.

This association is used mainly for grazing. Capability unit VIe–1; Loamy Salt Desert range site.

Gateway Series

The Gateway series consists of moderately deep, well-drained soils. These soils formed in residuum from shale on hills and mountain sides. The slope is 2 to 60 percent, and elevation is 8,000 to 9,500 feet. The natural vegetation is mainly spruce, fir, aspen, and grasses of the subalpine zone. The average annual precipitation is 20 inches. The mean annual temperature is 40° F., and the frost-free season is 35 to 50 days.

In a representative profile, beneath a 5-inch layer of organic material, the surface layer is light brownish-gray loam about 10 inches thick. The next layer is light brownish-gray silty clay loam about 5 inches thick. The subsoil is yellowish-brown silty clay about 15 inches thick. It is underlain by noncalcareous shale and soft sandstone at a depth of about 30 inches.

Gateway soils have slow permeability and a low or moderate available water capacity. They are slightly acid. Roots can penetrate to a depth of 20 to 40 inches.

These soils are used for timber, grazing, and watershed.

Representative profile of Gateway loam, in an area of Gateway-Cebone-Bangston association, NE¼ sec. 8, T. 14 S., R. 10 W., in an area of timber.

O1—5 inches to 1 inch, undecomposed organic material, mainly bark, twigs, needles, and grass.

O2—1 inch to 0, partly decomposed organic material.

A2—0 to 10 inches, light brownish-gray (10YR 6/2) loam, dark grayish brown (10YR 4/2) when moist; weak, medium, platy parting to weak, fine, granular structure; vesicular; soft, very friable; slightly acid; gradual, wavy boundary.

A&B—10 to 15 inches, light brownish-gray (10YR 6/2) silty clay loam, dark grayish brown (10YR 4/2) when moist; common, yellowish-brown (10YR 5/4) nodules and seams of more clayey material, dark yellowish brown (10YR 4/4) when moist; weak, medium, subangular blocky structure; very hard, friable; few films of clay on peds and in

some root channels; slightly acid; gradual, wavy boundary.

B2t—15 to 30 inches, yellowish-brown (10YR 5/4) silty clay, dark yellowish brown (10YR 4/4) when moist; weak, medium, prismatic parting to moderate, medium, angular blocky structure; extremely hard, very plastic; thin continuous films of clay on faces of peds and in root channels; slightly acid; clear, wavy boundary.

IIC—30 to 40 inches, noncalcareous shale and interbedded soft sandstone.

The A2 horizon is loam or very fine sandy loam. Depth to sandstone bedrock ranges from 20 to 40 inches.

GcE—Gateway-Cebone-Bangston association, steep. This association consists of about 35 percent Gateway loam, 30 percent Cebone loam, and 25 percent Bangston sandy loam. These soils are on mountainsides and ridges. The slope is 2 to 40 percent. Each soil has the profile described as representative of its series.

Included with this association in mapping are areas of Rock outcrop and Mayflower soils.

Runoff is moderate to rapid. The hazard of erosion is moderate to high.

This association is mostly in woodland. Areas that have been burned or logged are covered by aspen trees and have a good, grazable understory of grasses, shrubs, and forbs. Southern and eastern exposures are commonly covered by ponderosa pine. Northern and western exposures are covered by Douglas-fir, subalpine fir, and Englemann spruce. The site index, or the average height of dominant and codominant trees at 100 years, is 57 to 70 feet for ponderosa pine and 70 to 80 for Englemann spruce and subalpine fir. These soils are moderately well suited to growing trees for timber. They are used for grazing, watershed, recreation, and as wildlife habitat. Growing Christmas trees in areas of Douglas-fir, subalpine fir, and spruce is an alternative use for these soils. Capability unit VIe–3; not placed in a range site.

GcF—Gateway-Cebone-Bangston association, very steep. This association consists of about 35 percent Gateway loam, 30 percent Cebone loam, and 25 percent Bangston sandy loam. The slope is 40 to 60 percent. These soils are on mountain sides and ridges.

Included with this association in mapping are minor areas of Rock outcrop and Skyway soils.

Runoff is rapid, and the hazard of water erosion is very high.

This association is in woodland. Fairly large areas that have been burned or logged are in aspen, southern and eastern exposures are mainly ponderosa pine and aspen, and northern and western exposures are mainly Englemann spruce and subalpine fir. Capability unit VIIe–2; not placed in a range site.

Gibbler Series

The Gibbler series consists of moderately deep, well-drained soils. These soils formed in eolian deposits weathered from sandstone on upland hills and ridges. The slope is 3 to 12 percent, and elevation is 6,500 to 7,500 feet. The natural vegetation is mainly sagebrush, rabbitbrush, wheatgrass, and bluegrass. The average annual precipitation is 16 inches. The mean annual temperature is 50° F., and the frost-free season is 100 to 125 days.

In a representative profile the surface layer is light reddish-brown fine sandy loam about 4 inches thick. The subsurface layer is pink, light fine sandy loam about 2 inches thick. The subsoil is reddish-brown clay and pink channery clay loam about 20 inches thick. Bedrock is at a depth of about 26 inches.

Gibbler soils have slow permeability and a low available water capacity. They are neutral in the upper 20 inches and moderately alkaline in the lower 6 inches. Roots can penetrate to a depth of 20 to 40 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Gibbler fine sandy loam, in an area of Gibbler-Witt association, undulating, SW¼ sec. 7, T. 49 S., R. 17 W., in an area of grass.

A1—0 to 4 inches, light reddish-brown (5YR 6/4) fine sandy loam, reddish brown (5YR 4/4) when moist; moderate, very fine, granular structure; soft, very friable; neutral; clear, smooth boundary.

A2—4 to 6 inches, pink (5YR 7/3) light fine sandy loam, reddish brown (5YR 5/3) when moist; moderate, thin, platy parting to strong, fine, granular structure; soft, very friable; neutral; abrupt, smooth boundary.

B2t—6 to 20 inches, reddish-brown (5YR 5/4) clay, reddish brown (5YR 4/4) when moist; strong, fine, prismatic parting to strong, fine, angular blocky structure; extremely hard, very sticky and very plastic; thin continuous films of clay on faces of peds and in root channels; neutral; clear, wavy boundary.

B3ca—20 to 26 inches, pink (5YR 8/4) channery heavy clay loam, light reddish brown (5YR 6/4) when moist; weak, medium, angular blocky structure; extremely hard, very sticky and very plastic; 15 percent fragments of sandstone; few thin films of clay on peds and in some root channels; some thin seams and concretions of calcium carbonate; moderately alkaline; abrupt, wavy boundary.

R—26 inches, hard sandstone bedrock.

Sandstone fragments make up as much as 15 percent of the soil. Depth to bedrock ranges from 20 to 40 inches.

GeC—Gibbler-Witt association, undulating. This association is on upland hills and ridges. It consists of about 50 percent Gibbler fine sandy loam and about 40 percent Witt fine sandy loam. The slope is about 3 to 12 percent. Each soil has the profile described as representative of its series.

Included with this association in mapping are small areas of Potts and Palma soils.

Runoff is moderate. The hazard of erosion is moderate.

This association is used mainly for grazing and as wildlife habitat. Capability unit VIe–2; Loamy Foothills range site.

Glenberg Series

The Glenberg series consists of deep, well-drained soils. These soils formed in alluvium on flood plains and fans. The slope is 0 to 8 percent, and elevation is 5,800 to 7,000 feet. The natural vegetation is mainly sagebrush, rabbitbrush, wheatgrass, and bluegrass. The average annual precipitation is 16 inches. The mean annual temperature is 50° F., and the frost-free season is 100 to 125 days.

In a representative profile the surface layer is brown sandy loam about 5 inches thick. The underlying layer

is brown sandy loam that extends to a depth of 60 inches or more.

Glenberg soils have rapid permeability and low or moderate available water capacity. They are moderately alkaline. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, crops, and as wildlife habitat.

Representative profile of Glenberg sandy loam, 0 to 3 percent slopes, NW¼ sec. 18, T. 12 S., R. 102 W., in an area of grass.

A1—0 to 5 inches, brown (7.5YR 5/2) sandy loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; slightly hard, very friable; calcareous; moderately alkaline; clear, wavy boundary.

C—5 to 60 inches, brown (7.5YR 5/4) sandy loam, dark brown (7.5YR 4/2) when moist; massive; slightly hard, friable; calcareous; moderately alkaline; thin lenses of dark-brown (7.5YR 3/2) loam and loamy sand in this layer.

The A1 horizon is fine sandy loam or sandy loam. The C horizon is sandy loam that is commonly stratified with lenses of loam or light clay loam.

GlA—Glenberg sandy loam, 0 to 3 percent slopes. This soil is nearly level and is on flood plains. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of soils that have a surface layer of loamy sand and some Palma soils.

Runoff is slow. The hazard of erosion is high. A few areas have active gully erosion. The soil is subject to flooding.

This soil is used mainly for grazing and as wildlife habitat. Small areas are irrigated for alfalfa, pasture, barley, and oats. Capability unit IIe–1 (irrigated), VIe–2 (nonirrigated); Sandy Foothills range site.

GlB—Glenberg sandy loam, 3 to 8 percent slopes. This soil is gently sloping and is on fans.

Included with this soil in mapping are a few small areas of Potts and Palma soils.

Runoff is moderate. The hazard of erosion is high. A few areas have active gully erosion. The soil is subject to flooding.

This soil is used for grazing and as wildlife habitat. Capability unit VIe–2; Sandy Foothills range site.

Gullied Land

Gu—Gullied land. This land type consists of stratified loamy, sandy and clayey material on terraces and fans of intermittent drainageways. The areas are dissected by many gullies 5 to 50 feet deep. Parts of these nearly level to gently sloping areas have a sparse cover of grasses and brush. Most of the precipitation in these areas carries much sediment as it runs off. Capability unit VIIIe–1; not placed in a range site.

Ildefonso Series

The Ildefonso series consists of deep, well-drained soils. These soils formed in cobbly and gravelly alluvial sediment on fans. The slope is 3 to 12 percent, and elevation is 5,200 to 5,600 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 11 inches. The mean annual temperature is 52° F., and the frost-free season is 140 to 165 days.

In a representative profile the surface layer is brown cobbly sandy loam about 5 inches thick. The underlying layers are light-brown cobbly sandy loam and pinkish-white very cobbly sandy loam that extend to a depth of 60 inches or more.

Ildefonso soils have rapid permeability and a low available water capacity. They are mildly alkaline or moderately alkaline. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Ildefonso cobbly sandy loam, 3 to 12 percent slopes, SW¼ sec. 25, T. 12 S., R. 98 W., in an area of grass.

A1—0 to 5 inches, brown (7.5YR 5/2) cobbly sandy loam, dark brown (7.5YR 4/2) when moist; moderate, medium and fine, granular structure; soft, very friable; calcareous; mildly alkaline; 20 to 30 percent basalt cobbles; clear, smooth boundary.

AC—5 to 14 inches, light-brown (7.5YR 6/4) cobbly sandy loam, brown (7.5YR 4/4) when moist; weak, medium, subangular blocky parting to weak, medium, granular structure; slightly hard, friable; calcareous; moderately alkaline; 20 to 30 percent basalt cobbles that have moderate coatings of lime on undersides; gradual, smooth boundary.

Cca—14 to 60 inches, pinkish-white (7.5YR 8/2) very cobbly sandy loam, light brown (7.5YR 6/3) when moist; massive; hard, friable; calcareous; moderately alkaline; visible lime in seams, streaks, and in concretions around stones; 40 to 60 percent basalt cobbles; gradual, smooth boundary.

Cobbles and stones make up 25 to 40 percent of the upper 3 feet of the soil and 40 to 60 percent of the material below that.

IdC—Ildefonso cobbly sandy loam, 3 to 12 percent slopes. This soil is gently sloping to rolling and is on alluvial fans. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Utaline and Scholle soils.

Runoff is moderate. The hazard of water erosion is moderate.

The soil is used mainly for grazing and as wildlife habitat. Capability unit VIIe–1; Stony Salt Desert range site.

Lazear Series

The Lazear series consists of shallow, well-drained soils. These soils formed in sandstone and sandy shale on hillcrests and ridges. The slope is 3 to 30 percent, and elevation is 5,000 to 6,000 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 12 inches. The mean annual temperature is 52° F., and the frost-free season is 160 to 175 days.

In a representative profile the surface layer is light brownish-gray gravelly loam about 4 inches thick. The underlying layer is light-brown gravelly loam about 10 inches thick over hard, calcareous, sandstone bedrock.

Lazear soils have moderate permeability and a low available water capacity. They are moderately alkaline. Roots can penetrate to a depth of 8 to 15 inches.

These soils are used for grazing, as wildlife habitat, and watershed areas.

Representative profile of Lazear gravelly loam, in an area of Lazear-Rock outcrop complex, 3 to 30 percent slopes, NW¼ sec. 32, T. 9 S., R. 103 W., in an area of grass.

A1—0 to 4 inches, light brownish-gray (10YR 6/2) gravelly loam, dark grayish brown (10YR 4/2) when moist; moderate, fine, granular structure; soft, very friable; 15 percent small fragments of sandstone; calcareous; moderately alkaline; clear, smooth boundary.

C—4 to 14 inches, light-brown (7.5YR 6/3) gravelly loam, dark brown (7.5YR 4/3) when moist; massive; slightly hard, very friable; 20 percent small fragments of sandstone; calcareous; moderately alkaline; abrupt, wavy boundary.

R—14 inches, hard calcareous sandstone bedrock.

The A horizon is gravelly sandy loam or gravelly loam. The depth to bedrock ranges from 8 to 15 inches.

LkE—Lazear-Rock outcrop complex, 3 to 30 percent slopes. This complex is made up of shallow, gently sloping to steep Lazear soils and areas of Rock outcrop on hillcrests and ridges. It consists of about 60 percent Lazear gravelly loam and 35 percent Rock outcrop. The Lazear soil has the profile described as representative of the series.

Included with this complex in mapping are small areas of Nelman soils.

Runoff is rapid, and the hazard of water erosion is high.

This complex is used mostly for grazing and as wildlife habitat. Lazear soil is in capability unit VIIe–1 and in Loamy Salt Desert range site; Rock outcrop was not placed in a capability group or in a range site.

Loma Series

The Loma series consists of deep, well-drained soils. These soils formed in eolian deposits from redbed formations on mesas. The slope is 0 to 3 percent, and elevation is 6,500 to 7,500 feet. The natural vegetation is mainly sagebrush, rabbitbrush, wheatgrass, and bluegrass. The annual precipitation is about 16 inches. The mean annual temperature is 50° F., and the frost-free season is 100 to 125 days.

In a representative profile the surface layer is brown loam about 5 inches thick. The subsoil is brown silty clay loam, reddish-gray silty clay, and reddish-brown clay loam about 23 inches thick. It is underlain by light reddish-brown silt loam that extends to a depth of 40 inches or more.

Loma soils have slow permeability and a high available water capacity. They are moderately alkaline. Roots can penetrate to a depth of 40 inches or more.

These soils are used for grazing, as wildlife habitat, and watershed areas.

Representative profile of Loma loam, NE¼ sec. 24, T. 12 S., R. 102 W., in an area of grass.

A1—0 to 5 inches, brown (7.5YR 5/3) loam, dark brown (7.5YR 3/3) when moist; strong, fine, granular structure; soft, very friable; calcareous; moderately alkaline; clear, smooth boundary.

B1—5 to 9 inches, brown (7.5YR 5/2) heavy silty clay loam, dark brown (7.5YR 3/2) when moist; strong, fine, subangular blocky parting to medium, granular structure; hard, very friable; few films of clay on peds; calcareous; moderately alkaline; clear, smooth boundary.

B21t—9 to 14 inches, reddish-gray (5YR 5/2) light silty clay, dark reddish brown (5YR 3/2) when moist; moderate, medium, prismatic parting to moderate, fine, blocky structure; extremely hard, friable; thin, nearly continuous films of clay on peds and in root channels and pores; calcareous; moderately alkaline; clear, smooth boundary.

B22t—14 to 21 inches, reddish-gray (5YR 5/2) light silty clay, dark, reddish gray (5YR 4/2) when moist; strong, medium, prismatic parting to strong, medium, blocky structure; extremely hard, friable; thin, continuous films of clay on peds and in root channels and pores; calcareous; moderately alkaline; gradual, wavy boundary.

B3ca—21 to 28 inches, reddish-brown (5YR 5/3) heavy clay loam, reddish brown (5YR 4/3) when moist; weak, medium, prismatic parting to moderate, medium, subangular and blocky structure; hard, friable; thin films of clay on peds and in root channels; some visible concretions or thin seams and streaks of secondary calcium carbonate; calcareous; moderately alkaline; gradual, wavy boundary.

Cca—28 to 40 inches, light reddish-brown (5YR 6/3) silt loam, reddish brown (5YR 5/3) when moist; massive; hard, very friable; some visible concretions or thin seams and streaks of secondary calcium carbonate; calcareous; moderately alkaline.

The fragments of sandstone make up as much as 15 percent, by volume, of the soil.

Lo—Loma loam. This soil is nearly level and is on mesa tops. It has the profile described as representative of the series. Included with this soil in mapping are small areas of Potts and Dominguez soils.

Runoff is slow. The hazard of soil blowing is slight, and that of water erosion is moderate. Gully erosion is active in some small areas.

This soil is used mostly for grazing and as wildlife habitat. It is well suited to livestock ponds or small reservoirs. Capability unit VIe–2; Loamy Foothills range site.

Mayflower Series

The Mayflower series consists of moderately deep, well-drained soils that formed in residuum from shale and sandy shale on upland hills and ridges. The slope is 5 to 40 percent, and elevation is 8,000 to 9,500 feet. The natural vegetation includes such grasses as Thurbers fescue, Columbia needlegrass, native bluegrass, and such shrubs as big sagebrush, silver sagebrush, snowberry, and cinquefoil. The average annual precipitation is 20 inches. The mean annual temperature is 38° F., and the frost-free season is 35 to 50 days.

In a representative profile the surface layer is reddish gray and reddish-brown silty clay that extends to interbedded shale and sandstone at a depth of about 32 inches.

Mayflower soils have slow permeability and a moderate available water capacity. They are neutral in the upper 26 inches and moderately alkaline in the lowermost 6 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Mayflower silt loam, in an area of Mayflower-Skyway association, rolling, SE¼ sec. 25, T. 14 S., R. 102 W., in an area of grass.

A1—0 to 4 inches, dark-gray (10YR 4/1) silt loam, black

(10YR 2/1) when moist; strong, fine, granular structure; soft, very friable; neutral; clear, smooth boundary.

B1—4 to 8 inches, dark-gray (10YR 4/1) heavy silt loam, black (10YR 2/1) when moist; moderate, fine, subangular structure; soft, very friable; neutral; clear, smooth boundary.

B21t—8 to 20 inches, reddish-gray (5YR 5/2) light silty clay, dark reddish brown (5YR 3/2) when moist; moderate, medium, prismatic parting to strong, fine, blocky structure; extremely hard, very plastic; thin continuous films of clay on peds and in root channels and pores; neutral; clear, smooth boundary.

B22t—20 to 26 inches, reddish-brown (5YR 5/3) light silty clay, reddish brown (5YR 4/3) when moist; moderate, coarse, prismatic parting to moderate, coarse, blocky structure; extremely hard, very plastic; thin continuous films of clay on peds and in root channels and pores; few slickensides; neutral; gradual, wavy boundary.

B3—26 to 32 inches, reddish-brown (5YR 5/3) light silty clay, reddish brown (5YR 4/3) when moist; weak, very coarse, prismatic parting to weak, very coarse, blocky structure; extremely hard, very plastic; few thin films of clay on peds and in root channels; many olive, gray, or dark reddish-brown chips of shale; calcareous; moderately alkaline; diffuse, wavy boundary.

IIc—32 to 60 inches, red and olive Morrison shale and interbedded sandstone.

Depth to shale ranges from 20 to 40 inches. Coarse fragments make up as much as 15 percent, by volume, of the soil but generally less than 5 percent.

MkD—Mayflower-Skyway association, rolling. This association is gently sloping to steep and is on upland hills and ridges. It consists of about 60 percent Mayflower silt loam and about 30 percent Skyway fine sandy loam. The slope ranges from 5 to 40 percent. Each soil has the profile described as representative of that series.

Included with this association in mapping are minor areas of Cebone and Gateway soils.

Runoff is moderate to rapid. The hazard of erosion is moderate to high.

This association is used mainly for grazing and as wildlife habitat. Capability unit VIe–2; Subalpine Loam range site.

Miracle Series

The Miracle series consists of moderately deep, well-drained soils. These soils formed in residuum from sandstone on upland hills and mesas. The slope is 3 to 30 percent, and elevation is 7,500 to 8,700 feet. The natural vegetation is mainly big sagebrush, rabbitbrush, wheatgrass, bluegrass, and needlegrass. The average annual precipitation is 20 inches. The mean annual temperature is 40° F., and the frost-free season is 35 to 60 days.

In a representative profile the surface layer is brown fine sandy loam about 4 inches thick. The subsoil is brown or reddish-brown sandy clay loam about 26 inches thick. It is underlain by hard reddish-brown sandstone.

Miracle soils have moderate permeability and low available water capacity. They are neutral. Roots can penetrate to a depth of 20 to 40 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Miracle fine sandy loam in an area of Miracle-Splitro association, undulating, SW¼ sec. 24, T. 13 S., R. 104 W., in an area of grass.

A1—0 to 4 inches, brown (7.5YR 5/2) fine sandy loam, very dark brown (7.5YR 2/2) when moist; strong, very fine, granular structure; soft, very friable; neutral; clear, smooth boundary.

B1—4 to 8 inches, brown (7.5YR 5/2) light sandy clay loam, very dark brown (7.5YR 2/2) when moist; moderate, fine, subangular blocky parting to moderate, medium, granular structure; slightly hard, very friable; few thin films of clay on peds; neutral; clear, smooth boundary.

B2t—8 to 30 inches, reddish-brown (5YR 5/3) sandy clay loam, reddish brown (5YR 4/4) when moist; moderate, fine, prismatic parting to strong, fine, blocky structure; very hard, very friable; moderately thick, continuous films of clay on peds and in root channels and pores; neutral; gradual, wavy boundary.

R—30 inches, hard, noncalcareous, reddish-brown sandstone.

The A1 horizon is fine sandy loam or loam. The B2t horizon is sandy clay loam or light clay loam. Depth to bedrock ranges from 20 to 40 inches.

MpC—Miracle-Splitro association, undulating. This association consists of about 50 percent Miracle fine sandy loam and 40 percent Splitro sandy loam. Each soil has the profile described as representative of its series. Miracle soils are on mesas and benches and have a slope of about 3 to 12 percent. Splitro soils are on mesa and bench edges and have a slope of 6 to 12 percent.

Included with this association in mapping are minor areas of Owen Creek soils and Rock outcrop.

Runoff is medium. The hazard of erosion is moderate to high.

This association is used for range. Capability unit VIe–2; Mountain Loam range site.

Nelman Series

The Nelman series consists of moderately deep, well-drained soils. These soils formed in residuum from sandstone on upland hills and ridges. The slope is 3 to 12 percent, and elevation is 4,800 to 5,800 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 12 inches. The mean annual temperature is 52° F., and the frost-free season is 125 to 165 days.

In a representative profile the surface layer is pinkish-gray sandy loam about 6 inches thick. The underlying layer is light-brown or pink fine sandy loam about 20 inches thick over hard calcareous sandstone.

Nelman soils have rapid permeability and a low available water capacity. They are moderately alkaline. Roots can penetrate to a depth of 20 to 40 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Nelman sandy loam, 3 to 12 percent slopes, SE¼ sec. 8, T. 3 S., R. 2 E., in an area of grass.

A1—0 to 6 inches, pinkish-gray (7.5YR 6/2) sandy loam, dark brown (7.5YR 4/2) when moist; moderate, fine, granular structure; soft, very friable; 5 percent fragments of sandstone; calcareous; moderately alkaline; clear, smooth boundary.

AC—6 to 10 inches, light brown (7.5YR 6/3) fine sandy loam, dark brown (7.5YR 4/3) when moist; weak, medium, subangular blocky parting to moderate,

fine, granular structure; slightly hard, very friable; 10 percent fragments of sandstone; calcareous; moderately alkaline; gradual, wavy boundary.

C—10 to 26 inches, pink (7.5YR 7/4) fine sandy loam, light brown (7.5YR 6/4) when moist; massive; slightly hard, very friable; 10 percent fragments of sandstone; few soft masses of secondary carbonates; calcareous; moderately alkaline; abrupt, wavy boundary.

R—26 inches, hard calcareous sandstone.

Depth to bedrock ranges from 20 to 40 inches. The A1 horizon is sandy loam or fine sandy loam.

NeC—Nelman sandy loam, 3 to 12 percent slopes. This soil is gently sloping to rolling and is on upland hills and ridges. It has the profile described as representative of the series.

Included with this soil in mapping are minor areas of Lazear soils and a few areas of Rock outcrop.

Runoff is rapid. The hazard of erosion is high.

This soil is used mainly for grazing and as wildlife habitat. Capability unit VIe–1; Loamy Salt Desert range site.

NlC—Nelman-Lazear sandy loams, 3 to 12 percent slopes. This complex is made up of gently sloping to rolling soils on upland hills and ridges. It consists of about 60 percent Nelman sandy loam and about 30 percent Lazear sandy loam. The Nelman soil has the profile described as representative of the series. The Lazear soil has a profile similar to the one described as representative of the series, but the surface layer is sandy loam.

Included with this complex in mapping are areas of Rock outcrop.

Runoff is rapid. The hazard of erosion is high.

These soils are used mainly for grazing and as wildlife habitat. Capability unit VIe–1; Loamy Salt Desert range site.

Owen Creek Series

The Owen Creek series consists of moderately deep, well-drained soils. These soils formed in residuum from shale on mountain sides and ridges. The slope is 3 to 30 percent, and elevation is 7,500 to 8,700 feet. The natural vegetation is mainly sagebrush, rabbitbrush, wheatgrass, and bluegrass. The average annual precipitation is 20 inches. The mean annual temperature is 40° F., and the frost-free season is 35 to 60 days.

In a representative profile the surface layer is dark grayish-brown fine sandy loam about 15 inches thick. The subsoil is brown sandy clay loam about 6 inches thick. The substratum is brown heavy clay loam about 9 inches thick over sandy shale and sandstone bedrock.

Owen Creek soils have slow permeability at a depth of about 30 inches and a low or moderate available water capacity. They are neutral in the upper 21 inches and mildly alkaline in the lowermost 9 inches. Roots can penetrate to a depth of 20 to 40 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Owen Creek sandy loam, in an area of Owen Creek-Miracle complex, 3 to 12 percent slopes, NW¼ sec. 17, T. 13 S., R. 101 W., in an area of range.

A11—0 to 15 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular parting to moderate, fine, granular structure; slightly hard, very friable; neutral; many fine roots; clear, smooth boundary.

B2t—15 to 21 inches, brown (7.5YR 4/4) heavy sandy clay loam, dark brown (7.5YR 4/4) when moist; moderate, medium, prismatic parting to moderate, medium, subangular blocky structure; hard, friable; thin continuous films of clay on peds; neutral; gradual, wavy boundary.

C—21 to 30 inches, brown (7.5YR 5/3) heavy clay loam or light clay, dark brown (7.5YR 4/4) when moist; massive; very hard, firm; calcareous in spots; mildly alkaline; clear, wavy boundary.

R—30 inches, sandstone and sandy shale.

Depth to bedrock ranges from 20 to 40 inches. Fragments of sandstone make up 5 to 20 percent, by volume, of the soil. The B2t horizon is sandy clay loam or light clay.

OcC—Owen Creek-Miracle complex, 3 to 12 percent slopes. This complex is made up of gently sloping to rolling soils on mountains and ridges. It consists of about 60 percent Owen Creek fine sandy loam and about 30 percent Miracle fine sandy loam. Each soil has the profile described as representative of its series.

Included with this complex in mapping are small areas of Splitro soils and a few areas of Rock outcrop.

Runoff is moderate. The hazard of erosion is moderate.

This complex is used mainly for grazing and as wildlife habitat. Capability unit VIe–2; Mountain Loam range site.

OcE—Owen Creek-Miracle complex, 12 to 30 percent slopes. This complex is made up of rolling to steep soils on mountain sides and ridges. It consists of about 60 percent Owen Creek fine sandy loam and about 30 percent Miracle fine sandy loam. The Owen Creek soil has a profile similar to the one described as representative of the series, but in some areas it has a surface layer of clay loam.

Included with this complex in mapping are small areas of Splitro soils and Rock outcrop.

Runoff is rapid. The hazard of erosion is high.

This complex is used mainly for grazing and as wildlife habitat. Capability unit VIe–2; Mountain Loam range site.

Palma Series

The Palma series consists of deep, well-drained soils. These soils formed in sandy eolian deposits on uplands. The slope is 3 to 12 percent, and elevation is 6,800 to 7,500 feet. The natural vegetation is mainly sagebrush, rabbitbrush, wheatgrass, and bluegrass. The average annual precipitation is 16 inches. The mean annual temperature is 50° F., and the frost-free season is 100 to 125 days.

In a representative profile the surface layer is reddish-brown sandy loam about 4 inches thick. The subsoil is reddish-brown or light reddish-brown fine sandy loam about 24 inches thick. Below this is pink or yellowish-red sandy loam that extends to a depth of 60 inches or more.

Palma soils have moderately rapid permeability and a moderate available water capacity. They are mildly alkaline in the upper 20 inches and moderately alkaline in the lowermost 40 inches. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, crops, and as wildlife habitat.

Representative profile of Palma sandy loam, 3 to 12 percent slopes, NW¼ sec. 20, T. 12 S., R. 103 W., in an area of grass.

A1—0 to 4 inches, reddish-brown (5YR 5/3) sandy loam, dark reddish brown (5YR 3/3) when moist; weak, very thin, platy parting to weak, fine, granular structure; soft, very friable; mildly alkaline; clear, smooth boundary.

B1—4 to 10 inches, reddish-brown (5YR 4/4) fine sandy loam, dark reddish brown (5YR 3/4) when moist; weak, medium, subangular blocky structure; slightly hard, very friable; thin patchy films of clay; mildly alkaline; clear, smooth boundary.

B2t—10 to 20 inches, reddish-brown (5YR 5/4) fine sandy loam; reddish brown (5YR 4/4) when moist; moderate, medium, subangular blocky structure; hard, friable; thin nearly continuous films of clay on peds; mildly alkaline; gradual, smooth boundary.

B3—20 to 28 inches, light reddish-brown (5YR 6/4) fine sandy loam, reddish brown (5YR 5/4) when moist; weak, medium, subangular blocky structure; hard, friable; thin patchy films of clay; calcareous; moderately alkaline; gradual, smooth boundary.

C1ca—28 to 40 inches, pink (5YR 7/4) sandy loam, light reddish brown (7.5YR 6/6) when moist; massive; hard, friable; calcareous; moderately alkaline; much visible lime; gradual, wavy boundary.

C2—40 to 60 inches, yellowish-red (5YR 4/6) sandy loam; yellowish red (5YR 4/6) when moist; massive; slightly hard, friable; calcareous; moderately alkaline.

The A horizon is fine sandy loam or sandy loam that has hue of 5YR or 7.5YR. The B2t horizon has hue of 2.5YR to 7.5YR.

PaC—Palma sandy loam, 3 to 12 percent slopes. This soil is gently sloping to rolling and is on uplands and mesas. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Potts and Batterson soils.

Runoff is moderate, and the hazard of water erosion is moderate.

This soil is used mainly for grazing by wildlife. A few small areas are irrigated, mainly areas in alfalfa or pasture. Capability unit IVe–1 (irrigated), VIe–2 (nonirrigated); Loamy Foothills range site.

Persayo Series

The Persayo series consists of shallow, well-drained soils. These soils formed in residuum that weathered from shale on upland hills and ridges. The slope is 3 to 25 percent, and elevation is 4,800 to 5,600 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 9 inches. The mean annual temperature is 52° F., and the frost-free season is 140 to 165 days.

In a representative profile the surface layer is pale-yellow silt loam about 5 inches thick. The underlying layer is light brownish-gray silt loam that extends to yellowish-brown shale at a depth of about 16 inches.

Persayo soils have moderately slow permeability and a low available water capacity. They are moderately alkaline. Roots can penetrate to a depth of about 10 to 20 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Persayo silt loam, 3 to 25 percent slopes, NE¼ sec. 12, T. 9 S., R. 103 W., in an area of grass.

A1—0 to 5 inches, pale-yellow (2.5YR 7/4) silt loam, light olive brown (2.5Y 5/4) when moist; first inch is vesicular; weak, fine, subangular blocky parting to weak, fine, granular structure; soft, very friable; calcareous; moderately alkaline; small, flat chips of sandstone common on surface; clear, smooth boundary.

C1—5 to 16 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; weak, medium, subangular blocky structure; hard, firm; calcareous; moderately alkaline; many chips of shale and crystals of gypsum in lowermost 4 inches; clear, smooth boundary.

C2—16 inches, yellowish-brown silty shale.

The A1 horizon is silt loam or silty clay loam. Depth to shale ranges from 10 to 20 inches. Chips of sandstone and shale make up 5 to 15 percent, by volume, of the soil.

PeD—Persayo silt loam, 3 to 25 percent slopes. This soil is gently sloping to steep and is on upland hills and ridges. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Chipeta soils and Badland.

Runoff is rapid. The hazard of erosion is high.

This soil is used mainly for grazing and as wildlife habitat. Capability unit VIIe–1; Silty Salt Desert range site.

Potts Series

The Potts series consists of deep, well-drained soils. These soils formed in eolian deposits on upland hills and ridges. The slope is 3 to 12 percent, and elevation is 6,500 to 7,500 feet. The natural vegetation is mainly sagebrush, rabbitbrush, and wheatgrass. The average annual precipitation is 16 inches. The mean annual temperature is 50° F., and the frost-free season is 100 to 125 days.

In a representative profile the surface layer is reddish-brown sandy loam about 4 inches thick. The subsoil is reddish-brown loam or clay loam and light reddish-brown loam about 20 inches thick. The substratum is light reddish-brown loam that extends to a depth of 60 inches or more.

Potts soils have moderate permeability and a high available water capacity. They are neutral in the upper 16 inches and mildly alkaline or moderately alkaline in the lowermost 44 inches. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Potts sandy loam, 3 to 12 percent slopes, NE¼SW¼ sec. 5, T. 13 S., R. 103 W., in an area of grass.

A1—0 to 4 inches, reddish-brown (5YR 4/4) sandy loam, dark reddish brown (5YR 3/4) when moist; weak or moderate, fine, granular structure; soft, very friable; neutral; clear, smooth boundary.

B1—4 to 8 inches, reddish-brown (5YR 4/4) loam, dark reddish brown (5YR 3/4) when moist; weak, medium, subangular blocky structure; slightly hard, very friable; neutral; clear, smooth boundary.

B21t—8 to 16 inches, reddish-brown (5YR 4/3) light clay loam, dark reddish brown (5YR 4/4) when moist; moderate, medium, subangular blocky structure;

hard, friable; neutral; thin, nearly continuous films of clay on peds; clear, smooth boundary.

B22t—16 to 18 inches, reddish-brown (5YR 5/4) light clay loam, reddish brown (5YR 4/4) when moist; moderate, medium, subangular blocky parting to moderate, medium and fine, subangular blocky structure; hard, friable; calcareous; mildly alkaline; very thin patchy films of clay on faces of peds; clear, smooth boundary.

B3ca—18 to 24 inches, light reddish-brown (5YR 6/3) loam, reddish brown (5YR 5/4) when moist; weak or moderate, medium, subangular blocky parting to moderate, medium and fine, subangular blocky structure; hard, friable, moderately alkaline; visible lime in seams and fine concretions; gradual, smooth boundary.

C1ca—24 to 40 inches, light reddish-brown (5YR 6/3) loam, reddish brown (5YR 4.5/4) when moist; massive; very hard, friable; calcareous; moderately alkaline; visible lime in streaks and fine concretions; gradual, smooth boundary.

C2—40 to 60 inches, light reddish-brown (5YR 6/3) loam, reddish brown (5YR 4/4) when moist; massive; calcareous; moderately alkaline.

The A and B horizons have a hue of 7.5YR or 5YR. The A1 horizon is sandy loam or fine sandy loam. The B2t horizon is loam or clay loam. Depth to bedrock is typically more than 60 inches, but in small areas it is as shallow as 40 inches.

PoC—Potts sandy loam, 3 to 12 percent slopes. This soil is gently sloping to rolling and is on upland hills and ridges. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Palma and Batterson soils.

Runoff is moderate. The hazard of erosion is moderate.

This soil is used mainly for grazing and as wildlife habitat. Capability unit IVe–1 (irrigated), VIe–2 (nonirrigated); Loamy Foothills range site.

Rock Land

Ro—Rock land. This mapping unit consists of very shallow soil that is less than 2 inches deep over bedrock. It is strewn with stones and sandstone boulders. Stones, boulders, and outcrops of bedrock cover 50 to 70 percent of the surface.

Included in mapping are small areas of Batterson and Lazear soils.

The vegetation consists mainly of moderate to dense stands of pinyon and juniper trees. Some areas have a sparse understory of sagebrush and grass.

This mapping unit is used mainly as watershed and wildlife areas and for scenic and recreation uses. Capability unit VIIs–1; not placed in a range site.

Rock Outcrop

Rp—Rock outcrop. This mapping unit consists mainly of rock outcrop on very steep slopes, canyon slopes, cliffs, and steep mesa edges. The rock is mainly granite, sandstone, and shale.

Included in mapping are minor areas of stony and gravelly soils and small areas of shallow and very shallow soils. This mapping unit occurs throughout the survey area. The plant cover ranges from little or none to a few trees, shrubs, forbs, and grass.

Because of very steep slopes and poor accessibility, livestock grazing is impractical. The areas are used mainly as wildlife habitat. Because of the slopes, excessive runoff and erosion are major management concerns. Maximum protection of the existing plant cover helps to slow runoff and protect the areas from further erosion. Capability unit VIIIs–1; not placed in a range site.

Scholle Series

The Scholle series consists of deep, well-drained soils. These soils formed on stony alluvium fans and uplands. The slope is 3 to 12 percent, and elevation is 5,500 to 7,000 feet. The natural vegetation is mainly sagebrush, rabbitbrush, wheatgrass, and bluegrass. The average annual precipitation is 16 inches. The mean annual temperature is 50° F., and the frost-free season is 100 to 125 days.

In a representative profile the surface layer is brown stony loam about 5 inches thick. The subsoil is brown stony silty clay loam about 7 inches thick. The substratum is pinkish-white stony loam that extends to a depth of 40 inches or more.

Scholle soils have moderate permeability and a moderate available water capacity. They are neutral in the surface layer and moderately alkaline below that. Roots can penetrate to a depth of 40 inches or more.

These soils are used for grazing, as wildlife habitat, and for watershed areas.

Representative profile of Scholle stony loam, 3 to 12 percent slopes, NW¼ sec. 19, T. 12 S., R. 97 W., in an area of grass.

A1—0 to 5 inches, brown (10YR 5/3) stony loam, dark brown (10YR 3/3) when moist; moderate, medium, granular structure; slightly hard, friable; 30 percent basalt stones; noncalcareous; neutral; clear, smooth boundary.

B2t—5 to 12 inches, brown (7.5YR 5/4) stony silty clay loam, dark brown (7.5YR 3/4) when moist; moderate, medium, prismatic parting to moderate to strong, medium and fine, subangular blocky structure; very hard, friable; thin, nearly continuous films of clay; 30 percent basalt stones and gravel; calcareous in the lower 3 inches; mildly alkaline; gradual, smooth boundary.

C1ca—12 to 25 inches, pinkish-white (7.5YR 8/2) stony loam, light brown (7.5YR 5.5/4) when moist; moderate, fine, subangular blocky structure; hard, friable; 35 percent stones and cobbles; calcareous; moderately alkaline; gradual, wavy boundary.

C2ca—25 to 40 inches, pinkish-white (7.5YR 8/2) stony loam; massive; hard, friable; calcareous; moderately alkaline; about 30 percent stones and cobbles.

The A1 horizon is stony fine sandy loam or stony loam. The B horizon is stony silty clay loam or stony clay loam.

ScC—Scholle stony loam, 3 to 12 percent slopes. This soil is gently sloping to rolling and is on uplands and fans. It has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of soils that have a less stony surface layer and areas of Ildefonso soils.

Runoff is moderate. The hazard of water erosion is moderate.

The soil is used mainly for grazing and as wildlife habitat. The native vegetation (fig. 2) is mainly big sagebrush, rabbitbrush, western wheatgrass, bluebunch wheatgrass, bluegrass, and scattered pinyon

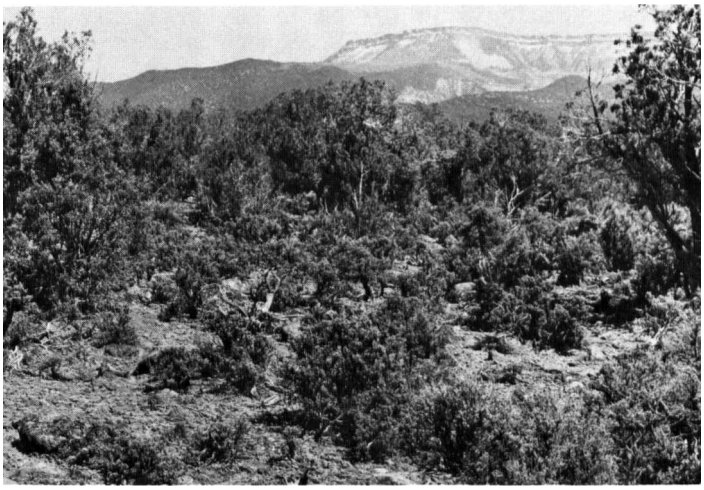


Figure 2.—Typical area of Scholle stony loam, 3 to 12 percent slopes.

and juniper trees. Capability unit VIe–2; Loamy Foothills range site.

Skyway Series

The Skyway series consists of moderately deep, well-drained soils. These soils formed in residuum from sandstone on mountain sides and mesas. The slope is 5 to 40 percent, and elevation is 8,000 to 9,500 feet. The natural vegetation is mainly sagebrush and grasses of the Subalpine zone. The average annual precipitation is 20 inches. The mean annual temperature is 38° F., and the frost-free season is 35 to 50 days.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 23 inches thick. The underlying layer is light brownish-gray fine sandy loam over hard sandstone bedrock at a depth of about 32 inches.

Skyway soils have moderately rapid permeability and a moderate available water capacity. They are neutral throughout. Roots can penetrate to a depth of about 20 to 40 inches.

These soils are used for grazing, as wildlife habitat, and as watershed areas.

Representative profile of Skyway fine sandy loam, in an area of Mayflower-Skyway association, rolling, SE¼ sec. 25, T. 14 S., R. 102 W., in an area of grass.

A11—0 to 8 inches, very dark gray (10YR 3/1) fine sandy loam, black (10YR 2/1) when moist; weak, fine, granular structure; soft, very friable; neutral; gradual, smooth boundary.

A12—8 to 23 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) when moist; weak, fine, subangular blocky parting to weak, fine, granular structure; slightly hard, very friable; neutral; clear, smooth boundary.

C—23 to 32 inches, light brownish-gray (10YR 6/2) fine sandy loam, brown (10YR 4/3) when moist; massive; hard, friable; 15 percent stones; neutral; abrupt, wavy boundary.

R—32 inches, sandstone.

Depth to bedrock ranges from 20 to 40 inches. Coarse fragments make up as much as 15 percent, by volume, of the soils. Skyway soils are mapped only in the Mayflower-Skyway association, rolling.

Splitro Series

The Splitro series consists of shallow, well-drained soils. These soils formed in residuum from sandstone on uplands, hills, and ridges. The slope is 6 to 12 percent, and elevation is 7,500 to 8,700 feet. The natural vegetation is mainly big sagebrush, rabbitbrush, wheatgrass, bluegrass, and needlegrass but includes sparse stands of oakbrush, ponderosa pine, aspen, pinyon, and juniper. The average annual precipitation is 20 inches. The mean annual temperature is 40° F., and the frost-free season is 35 to 60 days.

In a representative profile the surface layer is brown sandy loam about 7 inches thick. The underlying layer is brown stony sandy loam over hard reddish-brown sandstone, which is at a depth of about 15 inches.

Splitro soils have rapid permeability and a low available water capacity. They are neutral. Roots can penetrate to a depth of 12 to 17 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Splitro sandy loam, in an area of Miracle-Splitro association, undulating, NW¼ sec. 27, T. 13 S., R. 102 W., in an area of grass.

A1—0 to 7 inches, brown (7.5YR 4/2) sandy loam, dark brown (7.5YR 3/2) when moist; weak, fine, crumb structure; slightly hard, very friable; neutral; clear, smooth boundary.

AC—7 to 15 inches, brown (7.5YR 5/2) stony sandy loam, dark brown (7.5YR 3/2) when moist; weak, medium, subangular blocky parting to weak, fine, granular structure; slightly hard, friable; about 30 percent fragments of sandstone; neutral; clear, wavy boundary.

R—15 inches, reddish-brown fractured sandstone.

The A1 horizon is sandy loam or stony sandy loam. Depth to bedrock ranges from 12 to 17 inches. Splitro soils are mapped only in the Miracle-Splitro association, undulating.

Stony Land

St—Stony land. This mapping unit is on moderately steep or steep colluvial or alluvial fans mainly in the Gateway part of the survey area. It consists of colluvial or alluvial materials derived from sandstone, granite, gneiss, and schist. The materials consist mainly of deposits of cobbles, boulders, and stones that are 10 to 200 feet thick or more.

Included in mapping are some areas of sandy loam or loamy sand 4 to 6 inches thick.

The water intake rate is very high, and the water holding capacity is low. The vegetation consists of scrubby pinyon and juniper, sparse grass, cottonthorn horsebrush, annual weeds, and cactus.

This mapping unit is used mainly as watershed and wildlife areas and for some scenic and recreation uses. Capability unit VIIs–1; not placed in a range site.

Uffens Series

The Uffens series consists of deep, well-drained soils that formed in sediment derived from mixed materials on mesas and terraces. The slope is 3 to 12 percent, and elevation is 4,800 to 5,100 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 9 inches.

The mean annual temperature is 54° F., and the frost-free season is 160 to 175 days.

In a representative profile the surface layer is pink loam about 5 inches thick. The subsoil is brown clay loam and pink loam about 11 inches thick. It is underlain by pink fine sandy loam that extends to a depth of 50 inches or more.

Uffens soils have moderately slow permeability and a high available water capacity. They are strongly alkaline or very strongly alkaline. Roots can penetrate to a depth of more than 50 inches.

These soils are used for grazing, as wildlife habitat, and as watershed areas.

Representative profile of Uffens loam, 3 to 12 percent slopes, SW¼NE¼ sec. 7, T. 1 N., R. 1 E., in an area of grass.

A1—0 to 5 inches, pink (7.5YR 7/4) loam, brown (7.5YR 5/4) when moist; moderate, medium, platy parting to moderately fine, granular structure; soft, very friable; calcareous; strongly alkaline; abrupt boundary.

B21t—5 to 11 inches, brown (7.5YR 5/4) clay loam, dark brown (7.5YR 4/4) when moist; strong, medium, prismatic, parting to strong, medium, subangular blocky structure; very hard, firm; continuous films of clay on peds; calcareous; strongly alkaline; clear, smooth boundary.

B22t—11 to 16 inches, pink (7.5YR 7/4) loam, dark brown (7.5YR 4/4) when moist; moderate, medium, prismatic, parting to moderate, medium, subangular blocky structure; slightly hard, firm; thin patchy films of clay on peds; calcareous; very strongly alkaline; gradual, smooth, boundary.

C—16 to 50 inches, pink (7.5YR 7/4) fine sandy loam, brown (7.5YR 5/4) when moist; massive; slightly hard, friable; calcareous; very strongly alkaline; 25 percent sandstone, gravel, and cobbles.

The A1 horizon is very fine sandy loam, silt loam, or loam. Gravel and cobbles make up as much as 25 percent, by volume, of the C horizon.

UfC—Uffens loam, 3 to 12 percent slopes. This soil is gently sloping to rolling and is on terraces and mesas. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Avalon soils and soils that have a surface layer of stony loam.

Runoff is moderate. The hazard of erosion is moderate.

This soil is used for grazing and as wildlife habitat. Capability unit VIIe–1; Salt Flats range site.

Unaweep Series

The Unaweep series consists of deep, well-drained soils. These soils formed in sediment derived from sedimentary rock on alluvial fans and valley side slopes. The slope is 3 to 12 percent, and elevation is 6,700 to 7,300 feet. The natural vegetation is mainly sagebrush, rabbitbrush, wheatgrass, needlegrass, and native bluegrass and a sparse overstory of pinyon, juniper, and oakbrush. The average annual precipitation is 16 inches. The mean annual temperature is 50° F., and the frost-free season is 100 to 125 days.

In a representative profile the surface layer is grayish-brown sandy loam and brown fine sandy loam about 10 inches thick. The subsoil is reddish-brown fine sandy loam about 8 inches thick. The substratum is reddish-brown fine sandy loam that extends to a depth of 60 inches or more.

Unaweep soils have moderately rapid permeability and a moderate or high available water capacity. They are neutral or mildly alkaline in the upper 18 inches and moderately alkaline in the lowermost 42 inches. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, as wildlife habitat, and as watershed areas.

Representative profile of Unaweep sandy loam, 3 to 12 percent slopes, SE¼ sec. 26, T. 14 S., R. 101 W., in an area of grass.

A1—0 to 4 inches, grayish-brown (10YR 5/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; moderate, very fine, granular structure; soft, very friable; common flakes of mica; neutral; clear, wavy boundary.

A12—4 to 10 inches, brown (7.5YR 5/3) fine sandy loam, dark brown (7.5YR 3/3) when moist; weak, coarse, subangular blocky parting to weak, fine, granular structure; slightly hard, very friable; common flakes of mica; about 5 percent fragments of sandstone; mildly alkaline; clear, smooth boundary.

B2—10 to 18 inches, reddish-brown (5YR 5/3) fine sandy loam, reddish brown (5YR 4/3) when moist; moderate, medium, prismatic parting to moderate, medium, subangular blocky structure; slightly hard, very friable; common flakes of mica; few, thin, glossy surfaces on some peds; mildly alkaline; gradual, wavy boundary.

C—18 to 60 inches, reddish-brown (5YR 5/3) fine sandy loam, reddish brown (5YR 4/3) when moist; massive; slightly hard, very friable; common flakes of mica; 5 percent fragments of sandstone; calcareous; moderately alkaline.

The soil is sandy loam or fine sandy loam throughout. Depth to calcareous material is 15 to 30 inches.

UnC—Unaweep sandy loam, 3 to 12 percent slopes. This soil is gently sloping to rolling and is on fans and valley side slopes. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of a soil that has a stony or cobbly surface layer. Also included are small areas of Stony land.

Runoff is moderate. The hazard of erosion is moderate.

This soil is used mainly for grazing and as wildlife habitat. A few small areas are irrigated for alfalfa or pasture. Capability unit IVe–1 (irrigated), VIe–2 (nonirrigated); Loamy Foothills range site.

Utaline Series

The Utaline series consists of deep, well-drained soils. These soils formed in sediment that weathered from basalt on mesas and high terraces. The slope is 3 to 25 percent, and elevation is 4,800 to 5,700 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 9 inches. The mean annual temperature is 52° F., and the frost-free season is 140 to 165 days.

In a representative profile the surface layer is pink stony loam about 4 inches thick. The underlying layer is pink, pinkish-white, and pinkish-gray very cobbly loam that extends to a depth of 60 inches or more.

Utaline soils have moderate permeability and a low available water capacity. They are moderately alka-

line. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, as wildlife habitat, and for watershed.

Representative profile of Utaline stony loam, 3 to 25 percent slopes, 500 feet south of the Delta-Mesa County line, SE¼NW¼ sec. 13, T. 4 S., R. 3 E., in an area of grass.

A1—0 to 4 inches, pink (7.5YR 7/4) stony loam, brown (7.5YR 5/4) when moist; moderate, medium, granular structure, but weak platy structure in upper 2 inches; 30 percent basalt stones and cobbles; slightly calcareous; moderately alkaline; clear, smooth boundary.

ACca—4 to 9 inches, pink (7.5YR 7/4) very cobbly loam, brown (7.5YR 5/4) when moist; weak, medium, subangular blocky structure; slightly hard, very friable; 50 percent basalt cobbles; some soft accumulation of calcium carbonate; moderately alkaline; gradual, wavy boundary.

C1ca—9 to 18 inches, pink (7.5YR 8/4) very cobbly loam, light brown (7.5YR 6/4) when moist; massive; slightly hard, friable; 50 percent basalt cobbles; calcareous; moderately alkaline; gradual, wavy boundary.

C2ca—18 to 40 inches, pinkish-white (7.5YR 8/2) very cobbly loam, pink (7.5YR 7/4) when moist; massive; slightly hard, friable; 75 percent basalt cobbles; much secondary calcium carbonate in finely divided form; moderately alkaline; diffuse, wavy boundary.

C3ca—40 to 60 inches, pinkish-gray (7.5YR 7/2) very cobbly loam, light brown (7.5YR 6/4) when moist; massive; slightly hard, friable; 80 percent basalt cobbles; much accumulated calcium carbonate but less than in C2ca horizon; moderately alkaline.

Fragments of basalt make up 35 to 85 percent, by volume, of the soil. The fine material is loam or clay loam.

UoD—Utaline stony loam, 3 to 25 percent slopes. This soil is gently sloping to steep and is on mesas and high terraces. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Ildefonso soils and of soils that are about 40 inches deep to shale.

Runoff is moderate to rapid. The hazard of water erosion is moderate or high.

This soil is used mainly for grazing and as wildlife habitat. Capability unit VIIe–1; Stony Salt Desert range site.

Us—Utaline-Shale outcrop complex. This complex is rolling to steep and is on mesa and terrace edges and breaks. It consists of about 65 percent Utaline stony loam and about 35 percent Shale outcrop. The Utaline soil has the profile described as representative of the series.

Included with this complex in mapping are a few small areas of Persayo soils.

Runoff is rapid. The hazard of water erosion is high.

This soil is used mainly for grazing and as wildlife habitat. Utaline soil is in capability unit VIIe–1 and in Stony Salt Desert range site; Shale outcrop was not placed in a capability group or in a range site.

Wet Alluvial Land

We—Wet alluvial land. This mapping unit consists of deep alluvium on stream bottoms, flood plains, and swales. This alluvium is highly stratified and is mainly sandy loam or fine sandy loam. The water table is high for at least part of the year. Vegetation is mostly rushes, sedges, and grasses. The growing season ranges from 50 to 75 days. Capability unit Vw–1; Mountain Meadow range site.

Witt Series

The Witt series consists of deep, well-drained soils. These soils formed in eolian deposits on upland hills and ridges. The slope is 3 to 12 percent, and elevation is 6,500 to 7,500 feet. The natural vegetation is mainly sagebrush, rabbitbrush, wheatgrass, and bluegrass. The average annual precipitation is 15 inches. The mean annual temperature is 50° F., and the frost-free season is 100 to 125 days.

In a representative profile the surface layer is reddish-brown fine sandy loam about 3 inches thick. The upper part of the subsoil is also reddish-brown fine sandy loam about 3 inches thick. The lower part of the subsoil is reddish-brown or reddish-yellow clay loam and pink silty clay loam about 41 inches thick. The substratum is pinkish-white loam that extends to bedrock, which is at a depth of about 58 inches.

Witt soils have moderate permeability and a high available water capacity. They are neutral to a depth of about 17 inches and moderately alkaline below that. Roots can penetrate to a depth of 50 to 60 inches. These soils are used for grazing, as wildlife habitat, and as watershed areas.

Representative profile of Witt fine sandy loam, in an area of Gibbler-Witt association, undulating, SW¼ sec. 7, T. 49 N., R. 17 W., in an area of grass.

A1—0 to 3 inches, reddish-brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) when moist; weak, medium, platy parting to weak, fine, granular structure; slightly hard, very friable; neutral; clear, smooth boundary.

B1—3 to 6 inches, reddish-brown (5YR 5/4) heavy fine sandy loam, reddish brown (5YR 4/4) when moist; weak, medium, subangular blocky structure; slightly hard, very friable; neutral; clear, smooth boundary.

B21t—6 to 17 inches, reddish-brown (5YR 5/4) clay loam, reddish brown (5YR 4/4) when moist; moderate, medium, prismatic parting to moderate, medium, subangular blocky structure; hard, friable; moderate continuous films of clay on peds; neutral; clear, smooth boundary.

B22t—17 to 23 inches, reddish-yellow (5YR 6/6) clay loam, yellowish red (5YR 5/6) when moist; moderate, medium, prismatic parting to moderate, medium, subangular blocky structure; hard, firm; moderate, nearly continuous films of clay on peds; calcareous; moderately alkaline; clear, wavy boundary.

IIB2tca—23 to 47 inches, pink (5YR 8/3) silty clay loam, light reddish brown (5YR 6/4) when moist; moderate, medium, prismatic parting to moderate, medium, subangular blocky structure; hard, firm; moderate, nearly continuous films of clay on peds; calcareous; moderately alkaline; clear, smooth boundary.

IICca—47 to 58 inches, pinkish-white (5YR 8/2) loam, pink (5YR 7/3) when moist; massive; very hard, firm; calcareous; moderately alkaline; abrupt, clear boundary.

IIR—58 inches, sandstone and shale.

The A horizon is fine sandy loam or loam. The B2t horizon is clay loam or clay. Witt soils are mapped only in the Gibbler-Witt association, undulating.

Youngston Series

The Youngston series consists of deep, well-drained soils. These soils formed in alluvium on flood plains and alluvial fans. The slope is 0 to 3 percent, and elevation is 4,800 to 5,400 feet. The natural vegetation is mainly saltbush, rabbitbrush, galleta, and Indian ricegrass. The average annual precipitation is 9 inches. The mean annual temperature is 52° F., and the frost-free season is 160 to 175 days.

In a representative profile the surface layer is light-gray loam about 4 inches thick. The underlying layers are light brownish-gray sandy loam, very pale brown loam, and pale-brown very fine sandy loam and loam that extend to a depth of 60 inches or more.

Youngston soils have moderate permeability and a high available water capacity. They are moderately alkaline. Roots can penetrate to a depth of more than 60 inches.

These soils are used for grazing, as wildlife habitat, and as watershed areas.

Representative profile of Youngston loam, NW¼ sec. 9, T. 2 N., R. 2 W., in an area of grass.

A1—0 to 4 inches, light-gray (10YR 7/2) loam, dark grayish brown (10YR 4/2) moist; weak, thin, platy parting to weak, fine, granular structure; soft, very friable; calcareous; moderately alkaline; clear, smooth boundary.

AC—4 to 8 inches, light brownish-gray (10YR 6/2) sandy loam, dark grayish brown (10YR 4/2) when moist; weak, thin, platy parting to weak, fine, granular structure; loose, very friable; calcareous; clear, smooth boundary.

C1—8 to 20 inches, very pale brown (10YR 7/3) loam, brown (10YR 5/3) when moist; weak, fine, subangular blocky parting to weak, fine, granular structure; slightly hard, friable; calcareous; moderately alkaline; clear, smooth boundary.

C2—20 to 38 inches, pale-brown (10YR 6/3) very fine sandy loam, dark brown (10YR 4/3) when moist; weak, fine, subangular blocky parting to weak, fine, granular structure; slightly hard, friable; calcareous; moderately alkaline; clear, smooth boundary.

C3—38 to 60 inches, pale-brown (10YR 6/3) loam, dark brown (10YR 4/3) when moist; massive; hard when dry, very friable when moist; calcareous; moderately alkaline.

The A1 is loam or very fine sandy loam. Coarse fragments make up as much as 15 percent, by volume, but commonly less than 5 percent of the soil.

Yo—Youngston loam. This soil is nearly level and is on flood plains and alluvial fans. It has the profile described as representative of the series.

Included with this soil in mapping are areas of Billings soils.

Runoff is slow to moderate. The hazard of erosion is moderate.

This soil is used mainly for grazing and as wildlife habitat. Capability unit VIe–1; Loamy Salt Desert range site.

Use and Management of the Soils

The soils in the Mesa County Area are used mainly for range. A small acreage is used for irrigated pasture, hay, and crops. This section discusses these uses and the suitability of the soils for roads, farm ponds, and other engineering structures. It also provides information on managing the soils for several land uses and for wildlife habitat.

Crops, Hay, and Pasture

The small acreage used for irrigated crops, hay, and pasture makes up less than 0.1 percent of the Mesa County Area. The main crops are barley, oats, and corn. Pasture and hay plantings are mainly alfalfa or a mixture of alfalfa or clover and brome or fescue grasses.

Estimated yields of crops are given in the discussion of individual capability units on the following pages. The range of yields given are those that can be expected from a reasonably high level of management which includes the following:

1. Using cropping systems that maintain good tilth and a high content of organic matter.
2. Controlling erosion to the maximum extent feasible, so that the quality of the soil is maintained or improved.
3. Maintaining a high level of fertility by using fertilizer in amounts recommended by the Colorado Agricultural Experiment Station.
4. Using crop residues to the fullest extent practicable to protect and improve the soil.
5. Following minimum tillage practices to reduce soil compaction and erosion.
6. Using adapted crop varieties.
7. Controlling weeds by tillage.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to horticultural crops or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range or engineering.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce

the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–1 or VIe–3. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in the Mesa County Area are described.

CAPABILITY UNIT IIe–1 (IRRIGATED)

Glenberg sandy loam, 0 to 3 percent slopes, is the only soil in this capability unit. It is deep, well-drained, and rapidly permeable. The available water capacity is low or moderate. The hazard of erosion is high. The average annual precipitation is about 16 inches, and the frost-free season is 100 to 125 days.

This soil is used for irrigated hayland and small grain. Under a high level of management the yield per acre of alfalfa hay is 3 to 5 tons; mixed clover and grass hay, 4 to 6 tons; and barley, 70 to 90 bushels.

The control of erosion and management of water are the major concerns in managing these soils. Improving irrigation methods, using crop residue, and other conservation practices help maintain a high rate of crop production and keep the soil in good condition.

CAPABILITY UNIT IIs–1 (IRRIGATED)

Billings silty clay loam is the only soil in this capability unit. It is deep, well-drained, and slowly permeable. The available water capacity is high. The hazard of erosion is moderate. The average annual precipitation is about 10 inches, and the frost-free season is 165 to 175 days.

This soil is suited to irrigated row crops, grain, pasture, and hay. Under a high level of management the yield per acre of alfalfa hay is 3 to 5 tons; corn, 125 bushels; barley, 90 bushels; and mixed clover and grass pasture yield 18 animal-unit-months of grazing.

The low intake rate and the slow percolation rate are the major concerns in managing these soils. Conservation practices, including managing irrigation water, using crop residue, and managing grazing, help maintain a high rate of crop production and good soil condition.

CAPABILITY UNIT IVe–1 (IRRIGATED)

This unit consists of deep, well-drained, moderately to rapidly permeable sandy loam soils. The slope is 3 to 12 percent. The available water capacity is moderate or high. The hazard of erosion is high or moderate. The average annual precipitation is about 16 inches, and the frost-free season is 100 to 125 days.

These soils are used for irrigated hay. Under a high level of management the yield per acre of alfalfa hay is 3 to 4 tons, and mixed clover and grass hay yield 4 to 6 tons.

Conservation practices such as contour irrigation and tillage practices that leave crop residue on the soil surface help control erosion and conserve moisture.

CAPABILITY UNIT Vw–1

This capability unit consists of Wet alluvial land, which is deep and poorly drained. The slope is 0 to 6 percent. The available water capacity is moderate. There is no hazard of erosion. The average annual precipitation is 16 to 20 inches, and the frost-free season is 50 to 75 days.

Wet alluvial land is used mainly for range and wildlife habitat.

CAPABILITY UNIT VIe–1

This unit consists of deep to shallow, well-drained, moderately to rapidly permeable sandy loam, loam, and gravelly loam soils. The slope is 0 to 25 percent. The available water capacity is low to high. The hazard of erosion is slight to high. The average annual precipitation is about 9 to 12 inches, and the frost-free season is 125 to 175 days.

These soils are used for range and wildlife habitat.

CAPABILITY UNIT VIe–2

This unit consists of shallow to deep, well-drained, slowly to very rapidly permeable stony loam, loam, fine sandy loam, silt loam, clay loam, sandy loam and loamy sand soils. The slope is 0 to 40 percent. The available water capacity is low to high. The hazard of

erosion is slight to high. The average annual precipitation is 15 to 20 inches, and the frost-free season is 35 to 125 days.

These soils are used for range and wildlife habitat.

CAPABILITY UNIT VIe–3

This unit consists of deep and moderately deep, well-drained, slowly to rapidly permeable loam and sandy loam soils. The slope is 0 to 40 percent. The available water capacity is moderate or low. The hazard of erosion is high. The average annual precipitation is about 20 inches, and the frost-free season is 35 to 50 days.

These soils are used mainly for wood production and wildlife habitat. Some areas are used for grazing cattle and sheep.

Conservation practices such as controlling fire, selective cutting of trees, and forest reseeding help maintain production and control erosion.

CAPABILITY UNIT VIIe–1

This unit consists of shallow to deep, slowly permeable to rapidly permeable loamy sand, cobbly sandy loam, loam, silt loam, silty clay, and stony loam soils. The slope is 3 to 30 percent. The available water capacity is low to high. The hazard of erosion is high or moderate. The average annual precipitation is 9 to 14 inches, and the frost-free season is 110 to 175 days.

These soils are used for range and wildlife.

CAPABILITY UNIT VIIe–2

This unit consists of deep and moderately deep, well-drained, slowly to rapidly permeable loam and sandy loam soils. The slope is 40 to 60 percent. The available water capacity is low or moderate. The hazard of erosion is very high. The average annual precipitation is about 20 inches, and the frost-free season is 35 to 50 days.

These soils are used for woodland, wildlife habitat, and as watershed areas.

Conservation practices such as limited selective cutting and reforestation help maintain forest production and wildlife cover and control erosion.

CAPABILITY UNIT VIIw–1

Bankard loamy sand is the only soil in this capability unit. It is deep, well-drained, and rapidly permeable. The slope is 1 to 5 percent. The available water capacity is low. The hazard of erosion is high or moderate. The average annual precipitation is about 10 inches, and the frost-free season is 165 to 175 days.

These soils are used for range and wildlife habitat. They are subject to flooding.

CAPABILITY UNIT VIIs–1

This unit consists of Rock land and Stony land. These areas are mostly deposits of cobbles, boulders, and stones. Outcrops of bedrock and small areas of very shallow soils are included. The slope is 3 to 60 percent. The available water capacity is low. The average annual precipitation is about 16 inches, and the frost-free season is 100 to 125 days.

Rock land and Stony land are poorly suited to grass. They are used mostly as wildlife habitat. Pinyon, juniper, sagebrush, and forbs are the major plants.

Controlling erosion is the major management concern. Conservation practices such as managing wildlife and controlling grazing help maintain or improve the present cover and control erosion.

CAPABILITY UNIT VIIs–2

Billings silty clay loam is the only soil in this capability unit. It is deep, well drained, and slowly permeable. The slope is 0 to 3 percent. The available water capacity is high. The average annual precipitation is about 10 inches, and the frost-free season is 165 to 175 days.

The soil is used for range and as wildlife habitat.

CAPABILITY UNIT VIIIe–1

This unit consists of Badland and Gullied land. The areas are severely eroded, are mostly barren, and have a very high hazard of erosion. Nearly all of the precipitation in these areas carries much sediment as it runs off.

This area is scenic. It is used as a place of refuge by many kinds of wildlife.

CAPABILITY UNIT VIIIw–1

This capability unit consists of Alluvial land. This land is gravelly and cobbly alluvium. The slope is 0 to 5 percent. The available water capacity is low. The average annual precipitation is 13 inches, and the frost-free season is 140 to 160 days. Flooding is common.

Alluvial land is suited mainly to wildlife habitat and limited grazing. It has value as a source of sand and gravel.

CAPABILITY UNIT VIIIs–1

This capability unit consists of Rock outcrop, which occurs on very steep slopes, canyon slopes, cliffs, and steep edges of mesas.

The areas provide some food and protection for many kinds of wildlife. Because the slope is very steep, excessive runoff and erosion are major concerns of management. Protecting the existing plant cover helps to slow runoff and protect the areas from erosion.

Range [2]

Soils that produce the same kinds, amounts and proportions of range plants are grouped into range sites. The potential, or climax, plant community consists of plants growing in a range site that has not undergone a drastic disturbance. Climax plant communities have no given composition and the kinds and amounts of plants can vary, within reasonable limits, from year to year and from place to place.

Any disturbance such as overuse by livestock, excessive burning, erosion, or plowing can change the climax plant community or completely destroy it if the disturbance is drastic. If a range site has not deteriorated significantly, secondary plants can reestablish the natural climax plant community.

When changes occur in the climax plant community because of use by livestock or other disturbances, some plants increase and others decrease. *Decreasers* are plants in the original community that tend to die out if heavily grazed. They are generally the tallest, most productive, and most palatable perennials. *Increasers*

[2] THOMAS K. EAMAN and FORREST C. MAHAFFEY, range conservationists, Soil Conservation Service, helped prepare this section.

are those plants that normally become more abundant as the decreasers decline. Generally they are shorter, and some are less palatable than decreasers. Plants that become established when more desirable ones decline are *invaders*.

Management programs for range generally try to increase desirable plants and restore rangeland to climax condition. Some programs are designed to create or maintain plant communities that fit specific needs in the grazing program, to provide for wildlife habitat or for other benefits.

In the following pages, the range sites of Mesa County Area are described and the climax plants and principal invaders on the sites are named. An estimate of the potential annual yield of air-dry herbage for each site if it is in excellent condition is also given. The soils in each site can be determined by referring to the "Guide to Mapping Units" at the back of this soil survey.

SALT FLATS RANGE SITE

The soils in this range site have a surface layer of fine sand, loamy sand, loam, and silty clay loam. They have slow to rapid permeability and a low to high available water capacity. The slope is 0 to 12 percent. Annual precipitation is about 10 inches, and most of it occurs as snow during October through April.

Some of the grasses, forbs, and shrubs in the potential plant community that tolerate highly saline soil are alkali sacaton, saltgrass, western wheatgrass, green molly, fourwing saltbush, and greasewood. The availability of moisture greatly affects the growth of these and other plants. The site receives water mainly from runoff from adjoining uplands or occasionally from overflowing streams.

Alkali sacaton makes up about 25 percent, by air-dry weight, of the plant community. Western wheatgrass makes up 10 percent; saltgrass, 7 percent; galleta, 5 percent; and other grasses, 8 percent. The forbs include green molly, which makes up 4 percent; globe mallow, 3 percent; and other forbs, 3 percent. The shrubs include four-wing saltbush, which makes up 10 percent; shadscale, 5 percent; greasewood, 4 percent; and other shrubs, 16 percent.

The total annual yield of the plant community, by air-dry weight, ranges from 600 pounds per acre in years of favorable moisture to 400 pounds in other years. About 75 percent of the yield is used as forage and browse for sheep and cattle.

Continued heavy grazing by livestock or other disturbance changes the kind and amount of plants in this range site. Alkali sacaton, four-wing saltbush, and western wheatgrass become less abundant, and they are replaced by greasewood and annual weeds such as kochia and Russian-thistle.

Conservation practices such as controlled grazing and deferred grazing help to maintain or improve the range condition and to control erosion. A good distribution of livestock grazing can be encouraged by selective placement of livestock watering facilities.

SILTY SALT DESERT RANGE SITE

The soils in this range site have a surface layer of silt loam. They have moderately slow or slow permeability and a low available water capacity. They range from nonsaline to moderately saline. The slope is 3 to 25 percent. Annual precipitation is about 9 inches, and most of it occurs as snow during October through April.

Some of the grasses, forbs, and shrubs in the potential plant community of this site need an arid environment and moderately saline soil. These plants are galleta, Indian ricegrass, Salina wildrye, rabbitbrush, and saltbush (fig. 3).

Galleta makes up about 35 percent, by air-dry weight, of the plant community. Indian ricegrass makes up 6 percent; Salina wildrye, 6 percent; squirreltail, 4 percent; and other grasses, 4 percent. The forbs include globe mallow, which makes up 3 percent; Hood's phlox, 2 percent; Indian paintbrush, 2 percent; and other forbs, 3 percent. The shrubs include shadscale, which makes up 15 percent; Douglas rabbitbrush, 5 percent; Gardner saltbush, 3 percent; big sagebrush, 2 percent; and other shrubs, 10 percent.

The total annual yield of the plant community, by air-dry weight, ranges from 650 pounds per acre in years of favorable moisture to 400 pounds in other years. About 60 percent of the yield is used as forage and browse for sheep and cattle.

Continued heavy grazing by livestock or other disturbance changes the kind and amount of plants in this range site. Galleta and Indian ricegrass become less abundant, and they are replaced by shadscale, pricklypear, and other less palatable plants.

Conservation practices such as controlling grazing and deferred grazing help maintain or improve the range condition and control erosion. A good distribution of livestock grazing can be encouraged by selective placement of livestock watering facilities.

CLAYEY SALT DESERT RANGE SITE

The soils in this range site have a surface layer of silty clay. They have slow permeability and a low available water capacity. The slope is 3 to 25 percent.

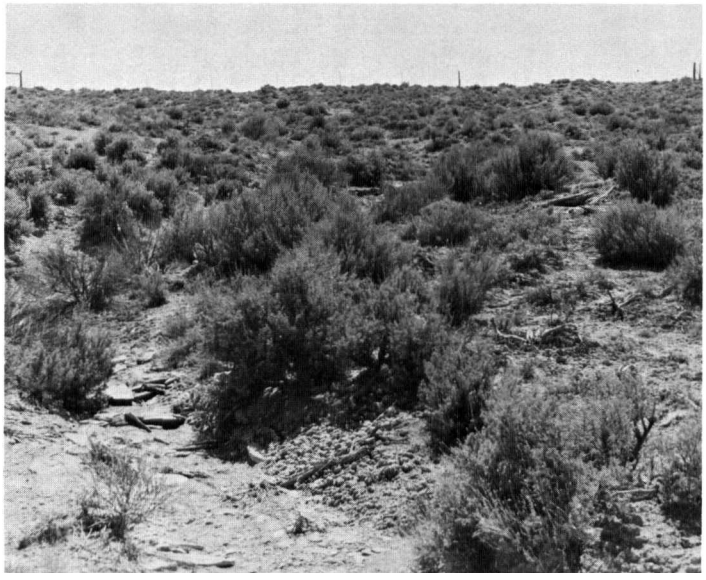


Figure 3.—**Silty Salt Desert range site in an area of Persayo silt loam, 3 to 25 percent slopes.**

Annual precipitation is about 9 inches, and most of it occurs as snow during October through April.

Shallow depth, high salinity, and slow permeability are the main influences on the kind and amount of plants. Only those plants that can adapt to and tolerate clayey and saline soils in an arid climate grow on this site. Saltbush is the main plant. A few grasses, forbs, and shrubs form a sparse ground cover.

Galleta makes up about 20 percent, by air-dry weight, of the plant community. Indian ricegrass makes up 5 percent; squirreltail, 3 percent; and other grasses, 7 percent. Forbs include globe mallow, which makes up 2 percent; sego lily, 1 percent; asters and fleabanes, 1 percent; and other forbs, 1 percent. The shrubs include shadscale, which makes up 30 percent; mat saltbush, 10 percent; Gardner saltbush, 5 percent; Douglas rabbitbrush, 3 percent; bud sagebrush, 2 percent; and other shrubs, 10 percent.

The total annual yield of the plant community, by air-dry weight, ranges from 500 pounds per acre in years of favorable moisture to 300 pounds in other years. About 50 to 60 percent of the yield is used as forage and browse for sheep and cattle.

Continued heavy grazing by livestock and other drastic disturbance can reduce this range site to a very sparse cover of prostrate saltbushes. Only a few grasses remain in the advanced stages of range deterioration.

Conservation practices such as controlled grazing and deferred grazing help maintain or improve the condition and control erosion. A good distribution of livestock grazing can be encouraged by selective placement of livestock watering facilities.

LOAMY SALT DESERT RANGE SITE

The soils in this range site have a surface layer of loam, stony loam, gravelly loam, and sandy loam. They have moderate to rapid permeability and a high to low available water capacity. The slope is 0 to 25 percent. Annual precipitation is about 9 to 12 inches, and most of it occurs as snow during October through April.

Grasses and shrubs are generally abundant in the potential plant community of this site. Galleta, Indian ricegrass, needleandthread, and squirreltail are the most common grasses, and shadscale and Gardner saltbush are common shrubs. The main forbs are biscuit root, globe mallow, Indian paintbrush, sego lily, and Hood's phlox.

Galleta makes up about 35 percent, by air-dry weight, of the plant community. Indian ricegrass makes up 5 percent; needleandthread, 5 percent; squirreltail, 3 percent; and other grasses, 2 percent. The forbs include Hood's phlox, which makes up 2 percent; globe mallow, 2 percent; buckwheat, 2 percent; loco, 1 percent; and other forbs, 3 percent. The shrubs include shadscale, which makes up 10 percent; Gardner saltbush, 8 percent; winterfat, 5 percent; Douglas rabbitbrush, 5 percent; snakeweed, 2 percent; and other shrubs, 10 percent.

The total annual yield of the plant community, by air-dry weight, ranges from 800 pounds per acre in years of favorable moisture to 500 pounds in other years. About 65 percent of the yield is used as forage for cattle.

Repeated overgrazing or other damaging disturbances change the kind and amount of plants on this range site. Galleta, Indian ricegrass, and most of the other grasses thin out and are partly replaced by cheatgrass, shadscale, pricklypear, and other less palatable plants.

Conservation practices such as controlled grazing use and deferred grazing help maintain or improve the range condition and control erosion. A good distribution of livestock grazing can be encouraged by fencing and by selective placement of livestock watering facilities.

STONY SALT DESERT RANGE SITE

The soils in this range site have a surface layer of stony loam or cobbly sandy loam. They have moderate permeability and low available water capacity. The slope is 3 to 25 percent. Annual precipitation is about 9 to 11 inches, and most of it occurs as snow during October through April.

Galleta and shadscale make up most of the plant community. Growing with these are Indian ricegrass, needleandthread, globe mallow, bud sagebrush, and pricklypear (fig. 4).

Galleta makes up about 30 percent, by air-dry weight, of the plant community. Indian ricegrass makes up 15 percent; needleandthread, 3 percent; squirreltail, 2 percent; and other grasses, 5 percent. The forbs include globe mallow, which makes up 3 percent; Indian paintbrush, 2 percent; Hood's phlox, 2 percent; and other forbs, 3 percent. The shrubs include shadscale, which makes up 20 percent; bud sagebrush, 5 percent; winterfat, 5 percent; Douglas rabbitbrush, 5 percent; and other shrubs, less than 1 percent.

The total annual yield of the plant community, by air-dry weight, ranges from 800 pounds per acre in years of favorable moisture to 500 pounds in other years. About 75 percent of the yield is used as forage for cattle.

Continued heavy grazing by livestock or other disturbance changes the kind and amount of plants in the range site. Snakeweed, pricklypear, and shadscale in-

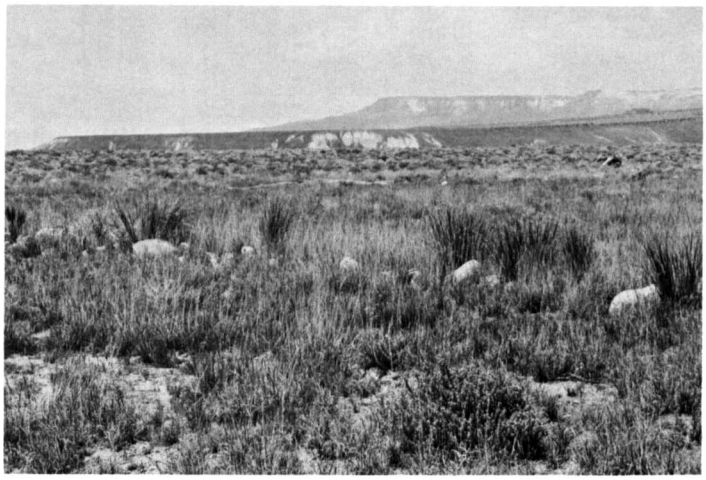


Figure 4.—**Stony Salt Desert range site in an area of Utaline stony loam, 3 to 25 percent slopes.**

crease sharply as galleta, Indian ricegrass, and other more palatable plants decline. Further deterioration of this site leaves much bare ground and only a few of the former perennial plants.

Conservation practices such as controlled grazing use and deferred grazing help maintain and improve the range condition and control erosion. A good distribution of livestock grazing can be encouraged by selective placement of livestock watering facilities.

LOAMY FOOTHILLS RANGE SITE

The soils in this range site have a surface layer of loam, fine sandy loam, stony loam, and sandy loam. They have slow to rapid permeability and a moderate or high available water capacity. The slope is 0 to 12 percent. Annual precipitation is about 16 inches, and most of it occurs as snow during October through April.

The potential plant community of this site is a nearly unbroken cover of grasses and an overstory of scattered big sagebrush. Western wheatgrass, Indian ricegrass, and muttongrass are the main plants in the cover. Lupine, penstemon, and Indian paintbrush are the main forbs. In addition to big sagebrush, there is a scattering of rabbitbrush, winterfat, four-wing saltbush, and other shrubs.

Western wheatgrass makes up about 30 percent, by air-dry weight, of the plant community. Indian ricegrass makes up 10 percent; muttongrass, 10 percent; bluebunch wheatgrass, 5 percent; needleandthread, 5 percent; squirreltail, 3 percent; and other grasses, 2 percent. The forbs include lupine, which makes up 3 percent; penstemon, 2 percent; Indian paintbrush, 2 percent; and other forbs, 3 percent. The shrubs include big sagebrush, which makes up 10 percent; Douglas rabbitbrush, 3 percent; four-wing saltbush, 3 percent; winterfat, 2 percent; bitterbrush, 2 percent; and other shrubs, 5 percent.

The total annual yield of the plant community, by air-dry weight, ranges from 1,500 pounds per acre in years of favorable moisture to 1,000 pounds in other years. About 67 percent of the total yield is used as forage and browse for cattle.

Continued overgrazing or other disturbance reduces the percentage of perennial grasses, especially bunch grasses, and increases big sagebrush, rabbitbrush, snakeweed, and other shrubs. Cheatgrass is one of the plants invading the site.

Conservation practices such as controlled grazing, deferred grazing, and brush management help maintain or improve the range condition and control erosion. Fencing and selective placement of livestock watering facilities help distribute livestock grazing. Areas that have deteriorated can be seeded to adapted plants.

SANDY FOOTHILLS RANGE SITE

The soils in this range site have a surface layer of loamy sand or sandy loam. They have very rapid or rapid permeability and a low or moderate available water capacity. The slope is 9 to 12 percent. Annual precipitation is about 16 inches, and most of it occurs as snow during October through April.

Indian ricegrass, needleandthread, and bluebunch wheatgrass make up the bulk of the cover in the potential plant community of this site. Other grasses are basin wildrye, blue grama, sand dropseed, and muttongrass. The major forbs are balsamroot, lupine, buckwheat, loco, penstemon, and globemallow. Big sagebrush, four-wing saltbush, Douglas rabbitbrush, and bitterbrush are the main shrubs (fig. 5).

Indian ricegrass makes up about 35 percent, by air-dry weight, of the plant community. Needleandthread makes up 10 percent; bluebunch wheatgrass, 10 percent; sand dropseed, 5 percent; and other grasses, 5 percent. The forbs include arrowleaf balsamroot, which makes up 5 percent; lupine, 2 percent; buckwheat, 2 percent; and other forbs, 1 percent. The shrubs include big sagebrush, which makes up 10 percent; four-wing saltbush, 5 percent; Douglas rabbitbrush, 3 percent; bitterbrush, 3 percent; and other shrubs, 4 percent.

The total annual yield of the plant community, by air-dry weight, ranges from 700 pounds per acre in years of favorable moisture to 600 pounds in other years. About 75 percent of the yield is used as forage and browse for cattle.

Continued overgrazing or other disturbance reduces the perennial bunchgrasses and increases shrubs, especially rabbitbrush. In large bare areas, cheatgrass and other annuals are invading. Wind erosion can be severe if an adequate plant cover is not maintained.

Conservation practices such as controlled grazing, deferred grazing, and brush management help maintain or improve the range condition and control erosion. Fencing and selective placement of livestock watering facilities help distribute livestock grazing. Areas that have deteriorated can be seeded to adapted plants.

CLAYEY FOOTHILLS RANGE SITE

The soils in this range site have a surface layer of clay loam. They have slow permeability and a high available water capacity. The slope is 3 to 12 percent. Annual precipitation is about 15 inches, and most of it occurs as snow during October through April.

Western wheatgrass is the major plant in the plant community of this site. This grass, muttongrass, beardless wheatgrass, Indian ricegrass, and other grasses make up more than half of the total plant cover. Buckwheat, globe mallow, yarrow, penstemon, and other forbs and such shrubs as big sagebrush, winterfat, pricklypear, and Douglas rabbitbrush are in the plant community.

Western wheatgrass makes up about 40 percent, by air-dry weight, of the plant community. Beardless wheatgrass makes up 5 percent; Indian ricegrass, 5 percent; muttongrass, 5 percent; squirreltail, 2 percent; and other grasses, 8 percent. The forbs include buckwheat, which makes up 2 percent; globemallow, 2 percent; yarrow, 2 percent; and other forbs, 4 percent. The shrubs include big sagebrush, which makes up 15 percent; winterfat, 4 percent; Douglas rabbitbrush, 3 percent; pricklypear, 1 percent; and other shrubs, 2 percent.

The total annual yield of the plant community, by air-dry weight, ranges from 1,200 pounds per acre in years of favorable moisture to 700 pounds in other years. About 75 percent of the yield is used as forage and browse for cattle.

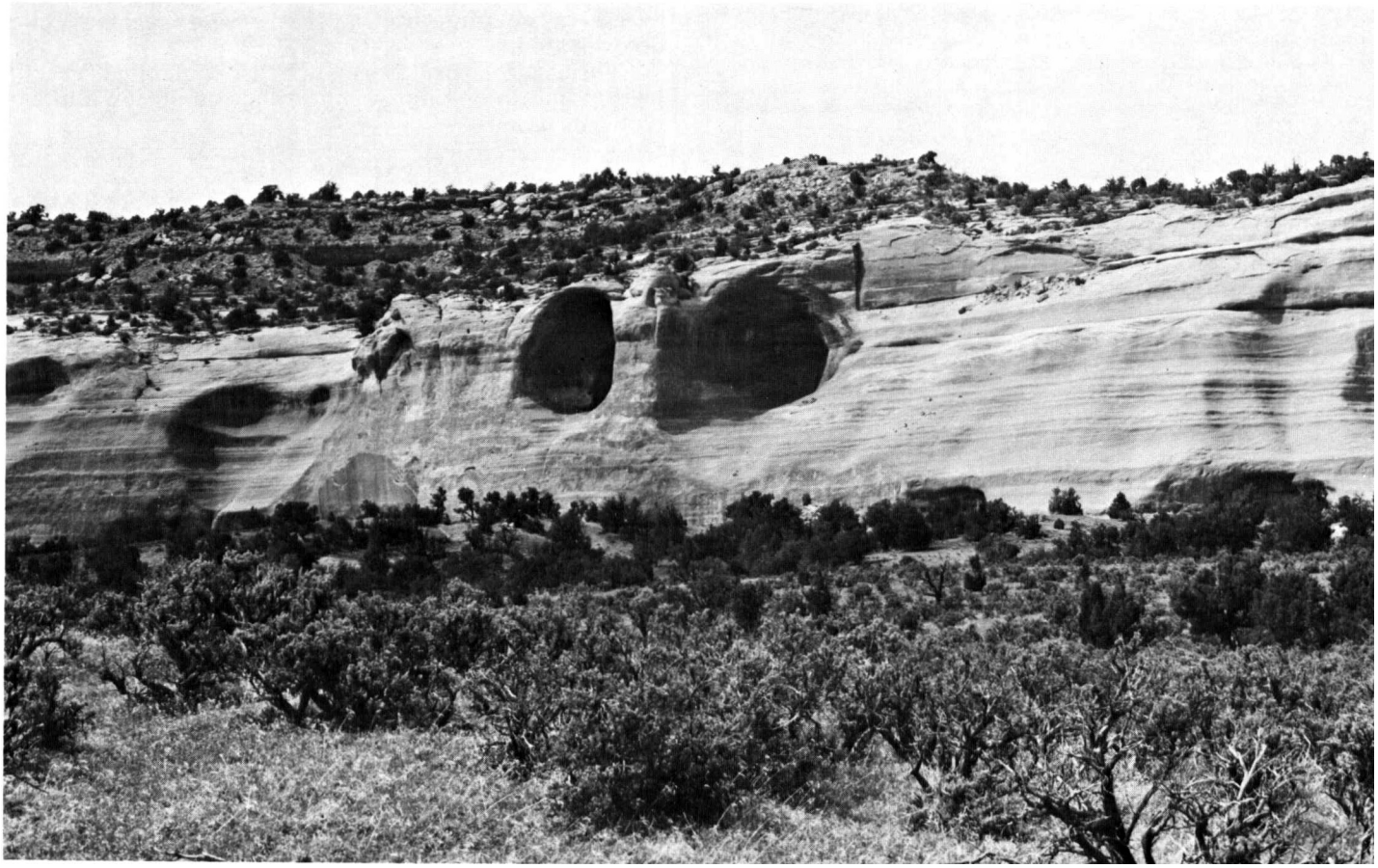


Figure 5.—**Sandy Foothills range site in an area of Dwyer loamy sand, 3 to 12 percent slopes. Rock outcrop is in the background.**

Continued heavy grazing and other major disturbances reduce the perennial grasses and increase big sagebrush, pricklypear, and rabbitbrush. Cheatgrass is a common invader if this site is allowed to deteriorate.

Conservation practices such as controlled grazing, deferred grazing, and brush management help maintain or improve the range condition and control erosion. Fencing and selective placement of livestock watering facilities help distribute grazing. Areas that have deteriorated can be seeded to adapted plants.

MOUNTAIN LOAM RANGE SITE

The soils in this range site have a surface layer of fine sandy loam, sand, and loam. They have slow to rapid permeability and a low or moderate available water capacity. The slope is 3 to 30 percent. Annual precipitation is about 20 inches, and most of it occurs as snow during September through May.

A mixture of grasses, forbs, and shrubs of the Intermediate Mountain zone makes up the potential plant community of this site. The main grasses are Arizona fescue, western wheatgrass, and muttongrass. Common forbs are geranium, lupine, larkspur, paintbrush, buckwheat, and herbaceous sage. Shrubs include big sagebrush, bitterbrush, serviceberry, and snowberry (fig. 6).

Arizona fescue makes up about 20 percent, by air-dry weight, of the plant community. Western wheatgrass makes up 15 percent; muttongrass, 15 percent; letterman's needlegrass, 5 percent; Sandberg bluegrass, 5 percent; nodding bromegrass, 5 percent; and other grasses, 7 percent. The forbs include American vetch, which makes up 2 percent; Indian paintbrush, 2 percent; silvery lupine, 1 percent; sulfur buckwheat, 1 percent; and other forbs, 5 percent. The shrubs include big sagebrush, which makes up 12 percent; snowberry, 2 percent; Douglas rabbitbrush, 1 percent; and other shrubs, 2 percent.

The total annual yield of the plant community, by air-dry weight, ranges from 1,800 pounds per acre in years of favorable moisture to 1,200 pounds in other years. About 75 percent of the yield is used as forage for cattle and sheep.

Continued heavy grazing or other disturbance greatly decreases the kinds and amounts of forage plants, and sagebrush, oakbrush, and annual weeds invade the site.

Conservation practices such as controlled grazing, deferred grazing, and brush management help maintain or improve the range condition and control erosion. Fencing and selective placement of livestock watering facilities can help distribute grazing. Areas that have deteriorated can be seeded to adapted plants.

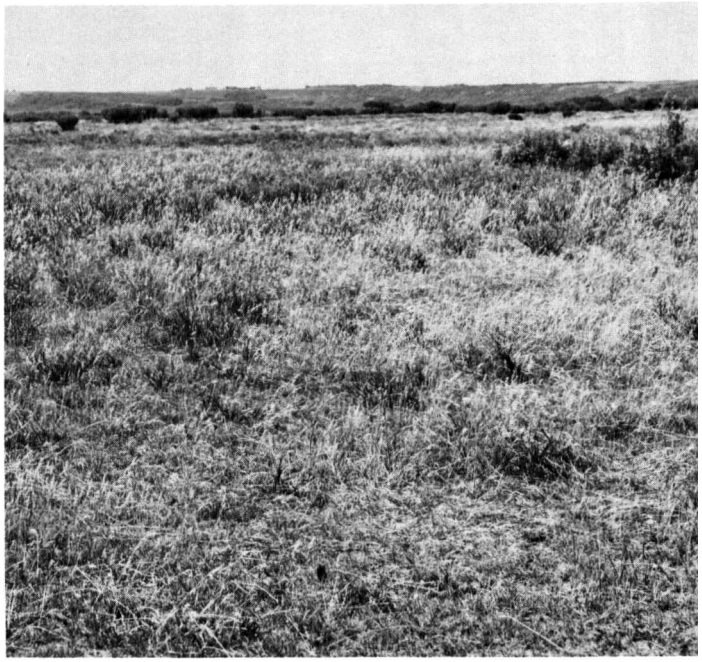


Figure 6.—**An area of Owen Creek-Miracle complex, 3 to 12 percent slopes, in the Mountain Loam range site.**

MOUNTAIN MEADOW RANGE SITE

This range site consists of Wet alluvial land. It mostly has a surface layer of fine sandy loam or sandy loam. The alluvium is highly stratified and has a high water table during part of the year. The slope is 0 to 6 percent. Annual precipitation is about 18 inches, and most of it occurs as snow during October through April. Poor drainage and a high water table are the main influences on the kind and amount of vegetation.

Grasses, sedges, rushes mixed with forbs, and some willows are the potential plant community of this site. The site is bounded in many places by streambank plants or forests. Plant growth is not controlled by seasonal precipitation because subsurface water is present (fig. 7).

Tufted hairgrass makes up about 40 percent of the plant community. Slender wheatgrass makes up 10 percent; Nebraska sedge, 5 percent; baltic rush, 5 percent; foxtail barley, 2 percent; and other grasses and grasslike plants, 16 percent. The forbs include cow parsnip, which makes up 5 percent; wild celery, 4 percent; Rocky Mountain iris, 2 percent; snowy cinquefoil, 2 percent; and other forbs, 5 percent. The shrubs include willow, which makes up 2 percent; and shrubby cinquefoil, 2 percent.

The total annual yield of the plant community fluctuates less on this site than on others. Moisture is available from the water table. The yield ranges from 4,000 pounds per acre, by air-dry weight, in years of favorable moisture to 3,000 pounds in other years. About 85 percent of the yield is used as forage for sheep and cattle.

Large numbers of livestock and overgrazing cause many of the most palatable forage plants to give way to less desirable plants. Broken sod, many weeds, and excessive gullying occurs if the site becomes more deteriorated.

Conservation practices such as controlled grazing help maintain or improve the range condition and control erosion.

SUBALPINE LOAM RANGE SITE

The soils in this range site have a surface layer of silt loam or fine loam. They have slow to moderately rapid permeability and a moderate available water capacity. The slope is 5 to 40 percent. Annual precipitation is about 20 inches, and most of it occurs as snow during September through May.

The potential plant community of this site is mainly tall bunchgrasses.

Thurbers fescue makes up about 40 percent, by air-dry weight, of the plant community. Bearded wheatgrass makes up 5 percent; Columbia needlegrass, 5 percent; needleandthread, 5 percent; mountain brome and nodding brome, 6 percent; and other grasses, 5 percent. The forbs include blue lupine, which makes up 5 percent; aspen peavine, 6 percent; and other forbs, 5 percent. The shrubs include silver sagebrush, which makes up 10 percent; snowberry, 3 percent; and other shrubs, 5 percent.

The total annual yield of the plant community, by air-dry weight, ranges from 4,000 pounds per acre in years of favorable moisture to 2,000 pounds in other years. About 85 to 90 percent of the yield is used as forage for sheep and cattle.

Severe disturbance of this site reduces the principal forage plants and increases the plants that are less palatable. Continued heavy grazing, repeated burning, or plowing are destructive disturbances that significantly change the plant community.

Conservation practices, such as controlled grazing, deferred grazing, selective placement of livestock watering facilities, and brush management, help maintain or improve the range condition and control erosion. Areas that have deteriorated can be seeded to adapted plants.

Wildlife

The Mesa County Area provides habitat for a variety of wildlife, including migratory animals and birds. The northern bald eagle spends winter along the major streams, and the rough-winged swallow stays in this area during summer and in Central America during winter. The major animals in the survey area include mule deer, elk, black bear, mountain lion, turkey, desert cottontail, blue grouse, chukar, ducks, and Canada geese.

Each kind of wildlife needs certain elements of habitat to survive and thrive. The major elements of habitat are food, cover, and water. Others include climate, weather, light, nutrients, atmospheric gases, temperature, and certain organisms. These factors generally are not controlled by man.

Soils differ in their ability to produce certain elements of habitat. A system was developed to indicate the degree to which various soils can provide these elements for different kinds of wildlife.

Most wildlife habitats are managed by planting

Figure 7.—**Mountain Meadow range site in an area of Wet alluvial land.**

suitable plants, manipulating existing plants to create a more natural plant community, or increasing or improving desired plants. Water areas also can be created or natural ones improved as wildlife habitats.

Soil interpretations for wildlife habitat help in selecting suitable sites for various kinds of management. They indicate the intensity of management needed to achieve satisfactory results. They also serve as a means of showing why it may not be feasible to manage a particular area for a given kind of wildlife. These interpretations also can help in broad-scale planning of wildlife management areas, parks, and nature areas, or in acquiring land for wildlife.

Each soil is rated according to its suitability for producing various kinds of plants and other elements that make up wildlife habitat. The ratings take into account mainly those characteristics of soils that are closely related to natural factors in the environment. They do not take into account climate, current use of soils, or distribution of wildlife and people. For this reason, a site should be inspected before development.

In table 2 the soils of this survey area are rated according to their suitability for producing seven elements of wildlife habitat and for four kinds of wildlife. The ratings that indicate relative suitability are explained in the following paragraphs.

Good means that the habitats are easily improved, maintained, or created. There are few or no soil limitations in habitat management, and satisfactory results can be expected.

Fair means that the habitats can be improved, maintained, or created on these soils, but moderate soil limitations affect habitat management or development. A moderate intensity of management and fairly frequent attention may be needed for satisfactory results.

Poor means that the habitats can be improved, maintained, or created on these soils but the soil limitations are severe. Habitat management may be difficult and expensive and may require intensive effort, and the results are generally marginal.

Very poor means that under the prevailing soil conditions, it is impractical to attempt to improve, maintain, or create habitats. Unsatisfactory results are probable.

Grain and seed include wheat, barley, oats, and other annual grain-producing plants.

Grass and legumes are established by planting. They provide food and cover for wildlife. The grasses include wheatgrasses, needlegrasses, and the legumes include alfalfa, yellow sweetclover, and other clovers.

Wild herbaceous plants consist of native or introduced perennial grasses, forbs, and weeds that provide food and cover for upland wildlife. Typical plants are

TABLE 2.

Soil series	Suitability for elements of wildlife habitat			
	Grain and seed	Grass and legumes	Wild herbaceous plants	Coniferous plants
Alluvial land: Ad	Very poor	Very poor	Fair	
Avalon: AvA, AvC	Poor	Poor	Poor	
Badland: Ba	Very poor	Very poor	Poor	
Bangston	Very poor	Very poor	Good	Good
Bankard: Bd	Poor	Fair	Fair	
Batterson: BrC For Rock outcrop part, see Rock outcrop.	Very poor	Very poor	Poor	Very poor
Billings: Bs.				
Irrigated	Fair	Fair	Good	Good
Nonirrigated	Very poor	Very poor	Very poor	Very poor
Blackston: BtD	Very poor	Very poor	Poor	
Cebone.				
2 to 25 percent slope	Poor	Poor	Good	Good
More than 25 percent slope	Very poor	Very poor	Good	Good
Chipeta: ChD	Very poor	Very poor	Very poor	Very poor
Dominguez: DoC	Poor	Poor	Fair	
Dwyer: DwC	Poor	Poor	Fair	Poor
Fruita: FaC For Avalon part, see that series.	Very poor	Very poor	Poor	
Gateway: GcE, GcF.				
2 to 25 percent slope	Poor	Poor	Good	Good
More than 25 percent slope For Bangston and Cebone parts, see those series.	Very poor	Very poor	Good	Good
Gibbler: GeC For Witt part, see that series.	Poor	Poor	Fair	Poor
Glenberg: GlA, GlB.				
Irrigated	Good	Good		
Nonirrigated	Fair	Fair	Fair	
Gullied land: Gu	Very poor	Very poor	Poor	
Ildefonso: IdC	Poor	Poor	Fair	
Lazear: LkE For Rock outcrop part, see Rock outcrop.	Very poor	Very poor	Fair	
Loma: Lo	Poor	Poor	Fair	
Mayflower: MkD For Skyway part, see that series.	Poor	Poor	Good	
Miracle: MpC For Splitro part, see that series.	Poor	Poor	Good	
Nelman: NeC, NlC For Lazear part of NlC, see that series.	Poor	Poor	Fair	
Owen Creek: OcC, OcE For Miracle part, see that series.	Poor	Poor	Good	

Wildlife

Suitability for elements of wildlife habitat—Cont'd.			Suitability for kinds of wildlife			
Shrubs	Wetland plants	Shallow water	Openland	Woodland	Wetland	Rangeland
Fair	Poor	Poor	Poor		Poor	Fair.
Poor	Poor	Very poor	Poor		Very poor	Poor.
Fair	Very poor	Very poor	Very poor		Very poor	Poor.
	Poor	Very poor	Poor	Fair	Very poor	
Fair	Very poor	Very poor	Fair		Very poor	Fair.
Fair	Very poor	Very poor	Poor		Very poor	Fair.
Good	Poor	Very poor	Fair	Good	Very poor	Good.
Poor	Poor	Very poor	Very poor	Very poor	Very poor	Poor.
Poor	Poor	Very poor	Very poor		Very poor	Poor.
Fair	Poor	Very poor	Fair	Good	Very poor	
Fair	Very poor	Very poor	Poor	Fair	Very poor	
Very poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor.
Fair	Poor	Very poor	Poor		Very poor	Fair.
Poor	Very poor	Very poor	Poor	Poor	Very poor	Poor.
Poor	Poor	Very poor	Very poor			Poor.
Fair	Poor	Very poor	Fair	Good	Very poor	
Fair	Very poor	Very poor	Poor	Fair	Very poor	
Fair	Poor	Very poor	Poor		Very poor	Fair.
			Good			
Fair	Poor	Poor	Fair		Very poor	Fair.
Fair	Poor	Poor	Very poor		Poor	Poor.
Fair	Poor	Very poor	Poor		Very poor	Fair.
Fair	Poor	Very poor	Poor		Very poor	Fair.
Fair	Poor	Very poor	Poor		Very poor	Fair.
Fair	Poor	Very poor	Fair		Very poor	Fair.
Fair	Poor	Very poor	Fair		Very poor	Fair.
Fair	Poor	Very poor	Fair		Very poor	Fair.
Good	Very poor	Very poor	Poor		Very poor	Good.

TABLE 2

Soil series	Suitability for elements of wildlife habitat			
	Grain and seed	Grass and legumes	Wild herbaceous plants	Coniferous plants
Palma: PaC	Poor	Fair	Fair	
Persayo: PeD	Very poor	Very poor	Poor	
Potts: PoC	Very poor	Poor	Fair	
Rock land: Ro	Very poor	Very poor	Fair	Fair
Rock outcrop: Rp	Very poor	Very poor	Poor	
Scholle: ScC	Poor	Fair	Fair	
Shale outcrop	Very poor	Very poor	Poor	
Skyway.				
2 to 25 percent slope	Poor	Poor	Good	
More than 25 percent slope	Very poor	Very poor	Good	
Splitro	Poor	Poor	Poor	
Stony land: St	Very poor	Very poor	Poor	
Uffens: UfC	Very poor	Very poor	Poor	
Unaweep: UnC	Poor	Poor	Fair	
Utaline: UoD, Us. For Shale outcrop part of Us, see that series.	Very poor	Very poor	Poor	
Wet alluvial land: We	Very poor	Poor	Good	
Witt	Poor	Fair	Fair	
Youngston: Yo	Poor	Poor	Poor	

alkali sacaton, western wheatgrass, winterfat, saltgrass, shadscale, Indian ricegrass, buckwheat, and fringed sage.

Coniferous plants are cone-bearing trees and shrubs that provide cover and frequently furnish food in the form of browse, seeds, or fruitlike cones. They commonly grow in their natural environment, but they may be planted and managed. Typical plants in this category are pine, juniper, and ornamental trees and shrubs.

Shrubs produce buds, twigs, bark, or foliage that are used as food by wildlife or that provide cover and shade for some kinds of wildlife. These plants generally grow in their natural environment. Typical plants in this category are bitterbrush, rabbitbrush, big sagebrush, mountainmahogany, and fruit-producing shrubs.

Wetland plants are annual and perennial herbaceous plants that grow wild on moist and wet sites. They furnish food and cover mostly for wetland wildlife. Typical examples of plants are smartweed, wildmillet, spikerush and other rushes, sedges, burreed, and barnyardgrass. Submerged and floating aquatic plants are not included in this category.

Shallow water includes areas of surface water that have an average depth of less than 5 feet and are useful to wildlife. The areas can be naturally wet areas or those made by dams or levees or by water-control devices in marshes or streams. Typical examples are waterfowl feeding areas, wildlife watering developments, wildlife ponds, and beaver ponds.

The soils also are rated according to their suitability for use as habitat for the four kinds of wildlife in the county.

Openland wildlife includes birds and mammals that use croplands, pasture, meadows, lawns, and areas overgrown with grasses, herbs, shrubs, and vines. Some of these are robin, mourning dove, meadowlark, field sparrow, killdeer, cottontail rabbit, and red fox.

Woodland wildlife includes birds and mammals that use areas of hardwood or coniferous trees and shrubs, or a mixture of both. Some of these are wild turkey, blue grouse, thrushes, vireos, woodpeckers, red squirrel, grey fox, raccoon, mule deer, elk, and black bear.

Wetland wildlife includes birds and mammals that use swampy, marshy, or openwater areas. Some of these are ducks, geese, herons, shore birds, rails, kingfishers, muskrat, and beaver.

Rangeland wildlife includes birds and mammals that use natural range areas. Some of these are ante-

Wildlife—Continued

Suitability for elements of wildlife habitat—cont.			Suitability for kinds of wildlife			
Shrubs	Wetland plants	Shallow water	Openand	Woodland	Wetland	Rangeland
Fair	Very poor	Very poor	Fair		Very poor	Fair.
Poor	Very poor	Very poor	Very poor		Very poor	Poor.
Fair	Poor	Very poor	Poor		Very poor	Fair.
	Very poor	Very poor	Poor	Fair	Very poor	
Poor	Very poor	Very poor	Very poor		Very poor	Poor.
Fair	Poor	Very poor	Fair		Very poor	Fair.
Poor	Very poor	Very poor	Very poor		Very poor	Poor.
Fair	Poor	Very poor	Fair		Very poor	Fair.
Fair	Very poor	Very poor	Poor		Very poor	Fair.
			Poor			
Poor	Very poor	Very poor	Very poor		Very poor	Poor.
Fair	Poor	Poor	Very poor		Very poor	Poor.
Fair	Poor	Very poor	Fair		Very poor	Fair.
Poor	Very poor	Very poor	Very poor		Very poor	Poor.
Fair	Good	Fair	Poor		Fair	Fair.
Poor	Poor	Very poor	Poor		Very poor	Poor.
Poor	Poor	Very poor	Poor		Very poor	Poor.

lope, desert cottontail, chukar, gambel's quail, western meadowlark, and the green-tailed towhee.

Engineering [3]

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Properties of soils highly important in engineering include permeability, strength, compaction characteristics, soil drainage, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables. Table 3 shows several estimated soil properties significant in engineering, and table 4 gives interpretations for various engineering uses.

This information, along with the soil map and other parts of this publication, can be used to make interpre-

[3] LLOYD G. LAUDENSCHLAGER, engineer, Soil Conservation Service, helped prepare this section.

TABLE 3.—*Estimated soil properties*

[Absence of data indicates that the soil is too variable to be rated or that no estimate was made. The symbol > means greater made up of two or more kinds of soil, which may have different properties and limitations. For this

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification		Coarse fraction greater than 3 inches	Percentage < 3 inches passing sieve—		
	Bedrock	Seasonal high water table			Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)
	In	*Ft*	*In*				*Pct*			
Alluvial land: Ad. Too variable to be estimated.										
Avalon: AvA, AvC.	>60	>6	0–44	Loam	CL–ML, CL	A–4	0	100	90–100	75–90
			44–59	Shale.						
Badland: Ba Too variable to be estimated.	>12	>6					0			
Bangston Mapped only with Gateway and Cebone soils.	>5	>6	0–9	Sandy loam	SM	A–2, A–4	0	75–100	75–100	40–70
			9–60	Loamy sand	SM	A–2, A–1	0	75–100	75–100	35–90
Bankard: Bd	>60	>6	0–60	Loamy sand, fine sand.	SP–SM, SM	A–2, A–3	0	95–100	80–100	50–75
Batterson: BrC Rock outcrop part is too variable to be estimated.	10–20	>6	0–15	Loamy sand	SM	A–2	0–10	75–100	75–100	50–75
			15	Sandstone.						
Billings: Bs	>60	>6	0–60	Silty clay loam.	CL	A–6	0	100	100	95–100
Blackston: BtD	>60	>6	0–14	Gravelly loam.	CL–ML, SM, SC	A–4, A–2	5–25	70–80	55–75	49–55
			14–28	Very gravelly loam.	GM	A–1	25–35	30–50	20–45	20–40
			28–60	Very cobbly sand.	GP	A–1	25–35	30–60	15–50	10–35
Cebone Mapped only with Gateway and Bangston soils.	20–40	>6	0–24	Loam, fine sand, loam.	SM	A–4	0	75–100	75–100	75–100
			24–38	Clay	CH, CL	A–7	0	75–100	75–100	75–100
			38	Shale.						
Chipeta: ChD	10–15	>6	0–12	Silty clay	CL	A–7, A–6	0	100	100	95–100
			12	Shale.						
Dominguez: DoC.	>4	>6	0–9	Clay loam	CL	A–7, A–6	0	100	95–100	85–90
			9–47	Clay	CH, CL	A–7, A–6	0	100	95–100	85–90
Dwyer: DwC	>60	>6	0–60	Loamy sand	SM	A–2	0	85–100	75–100	50–80
*Fruita: FaC For Avalon part, see that series.	>60	>6	0–5	Loam	ML, CL–ML	A–4	0–5	90–100	80–100	75–90
			5–60	Clay loam, loam.	CL	A–6	0–5	90–100	90–100	75–90
*Gateway: GcE, GcF. For Bangston and Cebone parts, see those series.	20–40	>6	0–10	Loam	ML	A–4	0	100	90–100	85–100
			10–15	Silty clay loam.	CL	A–6, A–7	0	100	100	95–100
			15–30	Silty clay	CL, CH	A–7	0	100	95–100	90–100
			30	Shale.						

significant in engineering

than; the symbol < means less than. An asterisk in the first column indicates that at least one mapping unit in this series is reason it is necessary to follow carefully the instructions for other series that appear in the first column]

Percentage < 3 inches passing sieve— Cont. No. 200 (0.074 mm)	Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
								Uncoated steel	Concrete
	Pct		*In/hr*	*In/in of soil*	*pH*	*Mmhos/cm at 25° C*			
50–70	20–30	5–10	0.6–2.0	0.13–0.19	7.9–8.4	2–8	Moderate	High	High.
25–45	NP [1]	NP [1]	2.0–6.0	0.10–0.15	6.6–7.3		Low	Low	Low.
15–25	NP	NP	6.0–20	0.05–0.08	6.6–7.3		Low	Low	Low.
5–25	NP	NP	6.0–20	0.05–0.08	7.9–8.4		Low	Low	Low.
15–25	NP	NP	6.0–20	0.05–0.08	7.9–8.4		Low	Low	Low.
90–95	25–40	11–20	0.06–0.2	0.19–0.21	7.9–8.4	2–8	Moderate	High	High.
20–35	20–25	5–10	0.6–2.0	0.11–0.14	7.9–8.4	0–4	Low	High	Moderate.
10–30	15–20	0–5	2.0–6.0	0.07–0.10	7.9–8.4	4–8	Low	High	Moderate.
0–5	NP	NP	6.0–20	0.03–0.06	7.9–8.4	4–8	Low	High	Moderate.
40–70	15–30	NP–4	0.6–2.0	0.13–0.16	6.6–7.3		Low	Moderate	Low.
60–80	40–60	20–35	0.06–02	0.14–0.17	6.6–7.3		High	Moderate	Low.
90–95	35–45	15–20	0.06–0.02	0.15–0.17	7.9–8.4	8–16	High	High	High.
75–85	35–45	15–35	0.06–0.20	0.15–0.18	7.9–8.4	0–4	High	High	Moderate.
75–85	35–60	15–35	0.06–0.20	0.13–0.15	7.9–8.4	0–4	High	High	Moderate.
15–35	NP	NP	>20	0.08–0.11	7.4–8.4	<2.0	Low	Low	Low.
50–70	20–30	0–10	0.6–2.0	0.15–0.17	7.4–7.8		Low	High	Low.
55–70	25–35	10–15	0.6–2.0	0.15–0.17	7.4–8.4		Low	High	Low.
60–85	30–40	NP–10	0.60–2.0	0.16–0.18	6.1–7.3		Low	High	Low.
85–95	35–50	15–25	0.20–0.6	0.16–0.18	6.1–7.3		Moderate	High	Low.
80–95	40–70	20–35	0.06–0.20	0.14–0.16	6.1–7.3		High	High	Low.

TABLE 3.—*Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification		Coarse fraction greater than 3 inches	Percentage < 3 inches passing sieve—		
	Bedrock	Seasonal high water table			Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)
	In	*Ft*	*In*				*Pct*			
*Gibbler: GeC — For Witt part, see that series.	20–40	>6	0–6	Fine sandy loam.	ML, SM	A–4	0	75–100	75–100	75–100
			6–20	Clay	CL, CH	A–7	0	75–100	75–100	75–100
			20–26	Clay loam	CL, CH	A–7	0–10	50–75	50–75	50–75
			26	Hard sandstone.						
Glenberg: GlA, GlB.	>60	>6	0–5	Fine sandy loam.	SM	A–4	0	95–100	85–100	75–90
			5–60	Sandy loam	SM	A–2, A–4	0	90–100	75–100	50–70
Gullied land: Gu. Too variable to be estimated.										
Ildefonso: IdC	>60	>6	0–14	Cobbly sandy loam.	SM, GM	A–1	20–30	50–70	45–60	30–45
			14–60	Very cobbly sandy loam.	GM	A–1	40–60	40–60	30–40	20–30
Lazear: LkE — Rock outcrop part is too variable to be estimated.	8–15	>6	0–14	Gravelly loam.	GM	A–4, A–2	0–5	50–75	50–75	40–65
			14	Hard sandstone.						
Loma: Lo	>60	>6	0–5	Loam	ML	A–4	0	75–100	75–100	75–95
			5–28	Silty clay	CL, CH	A–6, A–7	0	75–100	75–100	75–100
			28–40	Silt loam	CL–ML, CL	A–4, A–6	0–5	75–100	75–100	75–95
*Mayflower: MkD — For Skyway part, see that series.	20–40	>6	0–8	Silt loam	ML	A–6, A–4	0	95–100	95–100	85–100
			8–32	Silty clay	CH, CL	A–7	0	95–100	95–100	90–100
			32	Shale.						
*Miracle: MpC — For Owen Creek and Splitro parts, see those series.	20–40	>6	0–4	Fine sandy loam.	SM	A–4	0	80–100	75–100	70–85
			4–30	Sandy clay loam.	SC, CL	A–6	0	80–100	75–100	70–90
			30	Sandstone.						
*Nelman: NeC, NlC. For Lazear part of NlC, see that series.	20–40	>6	0–26	Fine sandy loam.	SM	A–4	0–10	75–100	75–100	60–80
			26	Sandstone.						
*Owen Creek: OcC, OcE. For Miracle parts, see that series.	20–40	>6	0–15	Fine sandy loam.	SM	A–4	0	85–100	75–100	70–85
			15–21	Sandy clay loam.	SC, CL	A–6	0	85–100	75–100	70–90
			21–30	Clay loam	CL, CH	A–7	0	85–100	75–100	75–95
			30	Shale.						
Palma: PaC	>60	>6	0–28	Sandy loam and fine sandy loam.	SM	A–4	0	100	100	70–90
			28–60	Sandy loam	SM	A–2	0	100	100	70–85
Persayo: PeD	10–20	>6	0–16	Silt loam	CL	A–6	0–10	90–100	80–100	80–95
			16	Shale.						

significant in engineering—Continued

Percentage < 3 inches passing sieve—Cont.	Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
								Uncoated steel	Concrete
No. 200 (0.074 mm)	*Pct*		*In/hr*	*In/in of soil*	*pH*	*Mmhos/cm at 25° C*			
35–55	15–30	NP–5	0.6–2.0	0.13–0.16	6.6–7.3		Low	Low	Low.
60–80	45–60	20–35	0.06–0.20	0.14–0.17	6.6–7.3		High	Moderate	Low.
45–70	40–60	20–35	0.06–0.20	0.12–0.15	7.9–8.4		High	High	Low.
35–45	NP	NP	2.0–6.0	0.09–0.13	7.9–8.4		Low	Low	Low.
25–40	NP	NP	6.0–20	0.07–0.12	7.9–8.4		Low	Low	Low.
15–25	NP	NP	2.0–6.0	0.06–0.08	7.4–8.4	0–2	Low	High	Low.
10–15	NP	NP	6.0–20	0.06–0.08		2–4			
30–50	20–30	NP–5	0.6–2.0	0.14–0.16	7.9–8.4		Low	High	Low.
55–75	15–25	NP–5	0.6–2.0	0.14–0.18	7.9–8.4		Low	High	Low.
70–95	35–60	15–35	0.06–0.2	0.15–0.17	8.9–8.4		High	High	Low.
70–90	20–40	5–15	0.6–2.0	0.15–0.17	7.9–8.4		Moderate	High	Low.
65–90	30–40	5–15	0.6–2.0	0.16–0.19	6.6–7.3		Low	Moderate	Low.
75–95	40–60	20–35	0.06–0.2	0.15–0.17	6.6–7.8		High	Moderate	Low.
35–50		NP	2.0–6.0	0.12–0.15	6.6–7.3		Low	Moderate	Low.
40–55	25–35	10–15	0.6–2.0	0.14–0.16	6.6–7.3		Low	Moderate	Low.
35–45		NP	6.0–20	0.09–0.14	7.9–8.4		Low	High	Low.
35–50	NP	NP–5	2.0–6.0	0.12–0.15	6.6–7.3		Low	High	Low.
45–60	25–35	10–15	0.6–2.0	0.14–0.16	6.6–7.3		Moderate	High	Low.
70–90	41–55	20–35	0.06–0.2	0.15–0.21	7.4–7.8		High	High	Low.
40–50	NP	NP	2.0–6.0	0.12–0.14	7.4–8.4		Low	Low	Low.
25–35	NP	NP	2.0–6.0	0.08–0.10	7.9–8.4		Low	Moderate	Low.
60–85	25–40	15–20	0.2–0.6	0.15–0.19	7.9–8.4	0–8	Moderate	High	High.

TABLE 3.—*Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification		Coarse fraction greater than 3 inches	Percentage < 3 inches passing sieve—		
	Bedrock	Seasonal high water table			Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)
	In	*Ft*	*In*				*Pct*			
Potts: PoC	>60	>6	0–4	Sandy loam	SM	A–4	0	75–100	75–100	60–75
			4–18	Clay loam	CL	A–6	0	75–100	75–100	65–95
			18–60	Loam	CL–ML	A–4	0	75–100	75–100	65–95
Rock land: Ro. Too variable to be estimated.										
Rock outcrop: Rp. Too variable to be estimated.										
Scholle: ScC	>60	>6	0–5	Stony loam	ML	A–4	20–30	80–100	75–100	70–95
			5–12	Stony silty clay loam.	CL, SC	A–6	20–30	60–80	50–75	50–75
			12–40	Stony loam	ML	A–4	30–40	60–80	75–100	70–95
Shale outcrop. Mapped only with Utaline soils. Too variable to be estimated.										
Skyway	20–40	>6	0–32	Fine sandy loam.	SM	A–2, A–4	0–10	90–100	75–100	60–80
Mapped only with Mayflower soils.			32	Sandstone.						
Splitro	12–17	>6	0–15	Sandy loam	SM	A–2, A–1	5–10	60–90	60–80	40–60
Mapped only with Miracle soils.			15	Sandstone.						
Stony land: St. Too variable to be estimated.										
Uffens: UfC	>60	>6	0–5	Loam	ML, CL	A–4, A–6	0	100	100	60–75
			5–11	Clay loam	CL	A–6	0	100	100	60–75
			11–16	Loam	ML, CL	A–4, A–6	0	100	100	60–75
			16–50	Fine sandy loam.	ML, CL–ML	A–4	10–20	100	100	60–75
Unaweep: UnC	>60	>6	0–10	Sandy loam, fine sandy loam.	SM	A–4, A–2	0–1	90–100	75–100	60–75
			10–60	Fine sandy loam.	SM	A–4, A–2	0	90–100	75–100	60–80
Utaline: Uod, Us. Shale outcrop part of Us is too variable to be estimated.	>60	>6	0–4	Stony loam	ML, GM	A–4, A–2	15–30	60–90	50–90	40–85
			4–60	Very cobbly loam.	GM	A–2, A–4	25–75	50–75	50–75	40–70

significant in engineering—Continued

Percentage < 3 inches passing sieve—Cont. No. 200 (0.074 mm)	Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity: Uncoated steel	Corrosivity: Concrete
	Pct		*In/hr*	*In/in of soil*	*pH*	*Mmhos/cm at 25° C*			
40–50	NP	NP	2.0–6.0	0.12–0.14	6.3–7.3	<2.0	Moderate	Low	Low.
50–75	30–35	15–20	0.6–2.0	0.19–0.21	6.6–7.8	<2.0	Moderate	Low	Low.
50–75	25–30	5–10	0.6–2.0	0.19–0.21	7.9–8.4	<2.0	Moderate	Moderate	Moderate.
55–75	20–25	NP–5	0.6–2.0	0.13–0.15	6.6–7.3		Low	Moderate	Low.
40–65	30–40	10–15	0.6–2.0	0.13–0.15	7.4–7.8		Moderate	Moderate	Moderate.
50–75	20–25	NP–5	0.6–2.0	0.10–0.12	7.9–8.4		Low	Moderate	Moderate.
30–50	25–35	NP–5	2.0–6.0	0.16–0.18	6.6–7.3		Low	Moderate	Low.
20–30	15–25	NP–5	2.0–6.0	0.11–0.13	6.6–7.3		Low	Low	Low.
55–65	25–40	5–20	0.2–0.6	0.17–0.18	8.5–9.0	15–30	Moderate	High	High.
60–70	25–40	10–20	0.2–0.6	0.17–0.18	8.5–9.0	15–30	Moderate	High	High.
55–65	25–40	5–20	0.2–0.6	0.17–0.18	>9.1	15–30	Moderate	High	High.
50–60	20–25	NP–10	0.2–0.6	0.17–0.18	>9.1	15–30	Moderate	High	High.
30–45	20–30	NP–5	2.0–6.0	0.14–0.16	6.6–7.8		Low	Moderate	Low.
30–50	20–30	NP–5	2.0–6.0	0.12–0.14	7.4–8.4		Low	High	Low.
30–65	20–30	NP–10	2.0–6.0	0.08–0.10	7.9–8.4		Low	Moderate	Low.
30–50	30–50	NP–10	2.0–6.0	0.04–0.08	7.9–8.4		Low	Moderate	Moderate.

TABLE 3.—*Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification		Coarse fraction greater than 3 inches	Percentage < 3 inches passing sieve—		
	Bedrock	Seasonal high water table			Unified	AASHTO		No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)
Wet alluvial land: We. Too variable to be estimated.	>60	>1								
Witt ---------- Mapped only with Gibbler soils.	>60	>6	0–6	Fine sandy loam, loam.	ML, CL–ML	A–4	0	100	100	95–100
			6–47	Clay loam, silty clay loam.	CL, ML	A–6	0	100	100	95–100
			47–58	Loam -------	ML, CL	A–4, A–6	0	100	100	95–100
			58	Sandstone and shale.						
Youngston: Yo --	>60	>6	0–4	Loam -------	CL–ML, CL	A–4	0	90–100	80–100	75–90
			4–8	Sandy loam--	SM	A–4, A–2	0	90–100	80–90	60–70
			8–60	Loam, very fine sandy loam.	ML, CL	A–4	0	90–100	80–100	75–90

[1] NP means nonplastic.

tations in addition to those given in tables 3 and 4, and it also can be used to make other useful maps.

This information, however, does not eliminate the need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to a depth greater than shown in the tables, generally a depth of more than 6 feet. Also, inspection of sites, especially the small ones, is needed because many mapped areas of one soil can contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists. The Glossary defines many of these terms.

Classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system used by SCS engineers, the Department of Defense, and others, and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO).

In the Unified system (*2*) soils are classified according to particle size distribution, plasticity, liquid limit, and organic matter. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, CL–ML.

The AASHTO system (*1*) is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and that are the poorest soils for subgrade.

Engineering properties

Several estimated soil properties significant in engineering are given in table 3. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the columns in table 3.

Depth to bedrock is distance from the surface of the soil to the upper surface of the rock layer.

Depth to seasonal high water table is distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in table 3 in the standard

significant in engineering—Continued

Percentage < 3 inches passing sieve—Cont. No. 200 (0.074 mm)	Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
								Uncoated steel	Concrete
70–80	20–30	NP–10	0.6–2.0	0.18–0.20	6.6–7.3		Low	High	Low.
75–85	30–40	10–15	0.6–2.0	0.18–0.20	6.6–8.4		Moderate	High	Low.
70–80	25–40	5–15	0.6–2.0	0.13–0.15	7.9–8.4		Low	High	Low.
50–70	20–30	5–10	0.6–2.0	0.15–0.17	7.9–8.4		Low	High	Low.
30–45	15–20	NP–5	2.0–6.0	0.14–0.16	7.9–8.4		Low	High	Low.
50–70	20–30	5–10	0.6–2.0	0.15–0.17	7.9–8.4		Low	High	Low.

terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from semisolid to plastic. If the moisture content is further increased, the material changes from plastic to liquid. The plastic limit is the moisture content at which the soil material changes from semisolid to plastic; and the liquid limit, from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 3.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 3 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Salinity refers to the amount of soluble salts in the soil. It is expressed as the electrical conductivity of the saturation extract, in mmhos per centimeter at 25° C. Salinity affects the suitability of a soil for crop production, its stability when used as construction material, and its corrosiveness to metals and concrete.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Corrosivity pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. Rate of corrosion of uncoated steel is re-

TABLE 4.—*Interpretations of*

["Shrink-swell" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definileast one mapping unit in this series is made up of two or more kinds of soil, which may have different properties and

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Roads and streets
Alluvial land: Ad. No interpretations made; properties too variable.				
Avalon: AvA, AvC	Slight where slope is 0 to 8 percent. Moderate where slope is more than 8 percent.[1]	Moderate where slope is 0 to 7 percent: seepage. Severe where slope is more than 7 percent: seepage; slope.	Moderate: shrink-swell; low strength.	Moderate: shrink-swell; low strength.
Badland: Ba. No interpretations made; properties too variable.				
Bangston Mapped only with Gateway and Cebone soils.	Slight where slope is 5 to 8 percent. Moderate where slope is 8 to 15 percent. Severe where slope is more than 15 percent: slope.	Severe: seepage	Slight where slope is 5 to 8 percent: slope. Moderate where slope is 8 to 15 percent: slope. Severe where slope is more than 15 percent: slope.	Slight where slope is 5 to 8 percent. Moderate where slope is 8 to 15 percent: slope. Severe where slope is more than 15 percent: slope.
Bankard: Bd	Severe: floods	Severe: floods; seepage	Severe: floods	Severe: floods
Batterson: BrC Properties too variable to rate for Rock outcrop part.	Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent; depth to rock: slope.	Severe where slope is 3 to 7 percent: depth to rock; seepage. Severe where slope is more than 7 percent: depth to rock; seepage; slope.	Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.
Billings: Bs	Severe: percs slowly	Slight where slope is 0 to 2 percent. Moderate where slope is more than 2 percent.	Severe: floods	Severe: low strength; frost action.
Blackston: BtD	Slight where slope is 3 to 8 percent.[1] Moderate where slope is 8 to 15 percent: slope. Severe where slope is more than 15 percent: slope.	Severe: seepage; slope.	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.
Cebone Mapped only with Gateway and Bangston soils.	Severe where slope is 2 to 15 percent: slope; depth to rock; percs slowly. Severe where slope is more than 15 percent: depth to rock; percs slowly; slope.	Severe: depth to rock; slope.	Severe where slope is 2 to 15 percent: shrink-swell; low strength. Severe where slope is more than 15 percent: shrink-swell; slope; low strength.	Severe where slope is 2 to 15 percent: shrink-swell; low strength. Severe where slope is more than 15 percent: shrink-swell; slope.

engineering properties of the soils

tions of "slight," "moderate," "good," "fair," and other terms used to rate soils. An asterisk in the first column indicates that at limitations. For this reason it is necessary to follow carefully the instructions for other series that appear in the first column.]

Degree and kind of limitations for—Continued	Suitability as source of—			Soil features affecting—	
Shallow excavations	Road fill	Sand	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments
Slight where slope is 0 to 8 percent. Moderate where slope is more than 8 percent.	Fair: shrink-swell; low strength.	Unsuited	Good where slope is 0 to 8 percent. Fair where slope is more than 8 percent.	Seepage; slope	Piping, low strength; shrink-swell.
Severe: cutbanks cave.	Good	Fair	Poor: too sandy	Seepage; slope	Seepage; piping.
Severe: floods, cutbanks cave.	Good	Fair	Poor: too sandy	Seepage	Piping; seepage; easily erodible.
Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Poor: thin layer	Unsuited	Poor: thin layer; small stones.	Depth to rock; slope.	Thin layer.
Moderate: floods	Poor: frost action; low strength.	Unsuited	Fair: too clayey	Favorable where slope is 0 to 2 percent. Fair where slope is more than 2 percent.	Low strength; piping; hard to rock.
Severe: cutbanks cave; small stones.	Good	Fair	Poor: small stones.	Seepage; slope	Seepage; small stones.
Severe where slope is 2 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Poor: thin layer; low strength; shrink-swell.	Unsuited	Good where slope is 2 to 8 percent. Fair where slope is 8 to 15 percent. Poor where slope is more than 15 percent.	Depth to rock; slope.	Compressible; low strength; shrink-swell.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Roads and streets
Chipeta: ChD	Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Severe where slope is 3 to 7 percent: depth to rock. Severe where slope is more than 7 percent: depth to rock; slope.	Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Severe where slope is 3 to 15 percent: depth to rock; low strength. Severe where slope is more than 15 percent: slope.
Dominguez: DoC	Severe: percs slowly	Moderate where slope is 3 to 7 percent: slope. Severe where slope is more than 7 percent: slope.	Severe: shrink-swell; low strength.	Severe: shrink-swell; low strength.
Dwyer: DwC	Slight where slope is 3 to 8 percent.[1] Moderate where slope is more than 8 percent: slope.	Severe where slope is 3 to 7 percent: seepage. Severe where slope is more than 7 percent: seepage; slope.	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.
*Fruita: FaC For Avalon part, see that series.	Slight where slope is 3 to 8 percent.[1] Moderate where slope is more than 8 percent: slope.	Moderate where slope is 3 to 7 percent: seepage; slope. Severe where slope is more than 7 percent: slope.	Moderate where slope is 3 to 8 percent: low strength. Moderate where slope is more than 8 percent: low strength; slope.	Severe: frost action
*Gateway: GcE, GcF For Bangston and Cebone parts, see those series.	Severe where slope is 2 to 15 percent: depth to rock; percs slowly. Severe where slope is more than 15 percent: depth to rock; percs slowly; slope.	Severe where slope is 2 to 7 percent: depth to rock. Severe where slope is more than 7 percent: depth to rock; slope.	Severe where slope is 2 to 15 percent: shrink-swell; low strength. Severe where slope is more than 15 percent: shrink-swell; slope.	Severe: low strength; shrink-swell.
*Gibbler: GeC For Witt part, see that series.	Severe: depth to rock; percs slowly.	Severe where slope is 3 to 7 percent: depth to rock. Severe where slope is more than 7 percent: depth to rock; slope.	Severe: shrink-swell; low strength.	Severe: shrink-swell; low strength.
Glenberg: GlA, GlB	Severe: floods	Severe: floods; seepage.	Severe: floods	Severe: floods
Gullied land: Gu No interpretations made; properties too variable.				
Ildefonso: IdC	Slight where slope is 3 to 8 percent.[1] Moderate where slope is more than 8 percent: slope.	Severe where slope is 3 to 7 percent: seepage. Moderate where slope is more than 7 percent: seepage; slope.	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.
Lazear: LkE No interpretations made for Rock outcrop part; properties too variable.	Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Severe where slope is 3 to 7 percent: depth to rock. Severe where slope is more than 7 percent: depth to rock; slope.	Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.

properties of the soils—Continued

Degree and kind of limitations for—Continued	Suitability as source of—			Soil features affecting—	
Shallow excavations	Road fill	Sand	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments
Severe: depth to rock	Poor: low strength; shrink-swell.	Unsuited	Poor: excess salt; too clayey.	Depth to rock; slope.	Low strength; hard to pack; compressible.
Severe: too clayey	Poor: shrink-swell; low strength.	Unsuited	Poor: too clayey	Slope	Shrink-swell; hard to pack; low strength.
Severe: cutbanks cave.	Good	Fair	Poor: too sandy	Seepage	Seepage; piping.
Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.	Poor: frost action.	Unsuited	Good where slope is 3 to 8 percent. Fair where slope is more than 8 percent: slope.	Seepage; slope	Low strength; piping.
Severe where slope is 2 to 15 percent: too clayey. Severe where slope is more than 15 percent: too clayey; slope.	Poor: low strength; shrink-swell.	Unsuited	Fair where slope is 2 to 15 percent: thin layer. Poor where slope is more than 15 percent: slope.	Slope; depth to rock.	Compressible; shrink-swell; low strength.
Severe: depth to rock	Poor: shrink-swell; thin layer; low strength.	Unsuited	Poor: thin layer	Depth to rock; slope.	Shrink-swell; compressible; low strength.
Severe: floods	Good	Poor	Good	Seepage	Piping.
Severe where slope is 3 to 15 percent: small stones.	Good	Poor	Poor: small stones; excess lime.	Seepage; slope	Favorable.
Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Poor: thin layer	Unsuited	Poor where slope is 3 to 15 percent: small stones; area reclaim. Poor where slope is more than 15 percent: small stones; area reclaim; slope.	Depth to rock; slope	Thin layer.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Roads and streets
Loma: Lo	Severe: percs slowly	Slight where slope is 0 to 2 percent. Moderate where slope is more than 2 percent: slope.	Moderate: low strength; shrink-swell.	Moderate: low strength; shrink-swell; frost action.
*Mayflower: MkD For Skyway part, see that series.	Severe where slope is 5 to 15 percent: percs slowly; depth to rock. Severe where slope is more than 15 percent: percs slowly; depth to rock; slope.	Severe where slope is 5 to 7 percent: depth to rock. Severe where slope is more than 7 percent: depth to rock; slope.	Severe where slope is 5 to 15 percent: shrink-swell; low strength. Severe where slope is more than 15 percent: shrink-swell; low strength; slope.	Severe where slope is 5 to 15 percent: shrink-swell; low strength. Severe where slope is more than 15 percent: shrink-swell; low strength; slope.
*Miracle: MpC For Owen Creek and Splitro parts, see those series.	Severe where slope is 3 to 15 percent: depth to rock.	Severe where slope is 3 to 7 percent: depth to rock. Severe where slope is more than 7 percent: depth to rock; slope.	Moderate where slope is 3 to 8 percent: depth to rock. Moderate where slope is 8 to 15 percent: depth to rock; slope.	Moderate where slope is 3 to 8 percent: depth to rock; frost action. Moderate where slope is 8 to 15 percent: depth to rock; frost action; slope.
*Nelman: NeC, NlC For Lazear part of NlC, see that series.	Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock.	Severe where slope is 3 to 7 percent: seepage; depth to rock. Severe where slope is more than 7 percent: seepage; depth to rock; slope.	Moderate where slope is 3 to 8 percent: depth to rock. Moderate where slope is 8 to 15 percent: depth to rock; slope.	Moderate where slope is 8 to 15 percent: frost action. Moderate where slope is 8 to 15 percent: frost action; slope. Severe where slope is more than 15 percent: slope.
*Owen Creek: OcC, OcE For Miracle parts, see that series.	Severe where slope is 3 to 15 percent: percs slowly; depth to rock. Severe where slope is more than 15 percent: percs slowly; slope; depth to rock.	Severe where slope is 3 to 7 percent: depth to rock. Severe where slope is more than 7 percent: depth to rock; slope.	Severe where slope is 3 to 15 percent: shrink-swell. Severe where slope is more than 15 percent: shrink-swell; slope.	Slight where slope is 3 to 8 percent. Moderate where slope is 8 to 15 percent: slope. Severe where slope is more than 15 percent: slope.
Palma: PaC	Slight where slope is 3 to 8 percent.[1] Moderate where slope is more than 8 percent.	Severe where slope is more than 3 percent: seepage.	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.	Moderate where slope is 3 to 8 percent: low strength. Moderate where slope is more than 8 percent: low strength; slope.
Persayo: PeD	Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock.	Severe where slope is 3 to 7 percent: depth to rock. Severe where slope is more than 7 percent: depth to rock; slope.	Moderate where slope is 3 to 8 percent: shrink-swell; depth to rock. Moderate where slope is 8 to 15 percent: shrink-swell; depth to rock; slope. Severe where slope is more than 15 percent: slope.	Moderate where slope is 3 to 8 percent: shrink-swell; depth to rock. Moderate where slope is 8 to 15 percent: shrink-swell; depth to rock; slope. Severe where slope is more than 15 percent: slope.

properties of the soils—Continued

Degree and kind of limitations for—Continued	Suitability as source of—			Soil features affecting—	
Shallow excavations	Road fill	Sand	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments
Moderate: too clayey	Fair: low strength; frost action; shrink-swell.	Unsuited	Fair: too clayey	Slope	Compressible; low strength.
Severe: depth to rock; too clayey.	Poor: shrink-swell; low strength; thin layer.	Unsuited	Fair where slope is 5 to 8 percent: thin layer. Fair where slope is more than 8 percent: thin layer; slope.	Depth to rock; slope.	Compressible; low strength; shrink-swell.
Severe where slope is 3 to 15 percent: depth to rock.	Poor: thin layer	Unsuited	Good where slope is 3 to 8 percent: slope. Fair where slope is 8 to 15 percent: slope.	Seepage; slope	Thin layer; piping.
Severe where slope is 3 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Poor where slope is 3 to 25 percent: thin layer. Poor where slope is more than 25 percent: slope; thin layer.	Unsuited	Fair where slope is 3 to 8 percent: area reclaim. Fair where slope is 8 to 15 percent: area reclaim; slope. Poor where slope is more than 15 percent: slope.	Seepage; slope	Piping; thin layer.
Severe where slope is 3 to 15 percent: too clayey. Severe where slope is more than 15 percent: too clayey; slope.	Poor where slope is 3 to 25 percent: thin layer. Poor where slope is more than 25 percent: thin layer; slope.	Unsuited	Fair where slope is 3 to 8 percent: thin layer; too clayey. Fair where slope is 8 to 15 percent: thin layer; too clayey; slope. Poor where slope is more than 15 percent: slope.	Depth to rock; slope.	Low strength; thin layer.
Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.	Fair: low strength.	Poor	Good	Seepage where slope is 3 to 7 percent. Seepage and slope where slope is more than 7 percent.	Piping; low strength.
Moderate where slope is 3 to 8 percent: depth to rock. Moderate where slope is 8 to 15 percent: depth to rock; slope. Severe where slope is more than 15 percent: slope.	Poor where slope is 3 to 25 percent: thin layer.	Unsuited	Poor where slope is 3 to 15 percent: area reclaim. Poor where slope is more than 15 percent: area reclaim; slope.	Slope; depth to rock.	Thin layer; compressible.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Roads and streets
Potts: PoC	Moderate where slope is 3 to 8 percent: percs slowly. Moderate where slope is 8 to 15 percent: percs slowly; slope.	Moderate where slope is 3 to 8 percent: seepage; slope. Severe where slope is more than 8 percent: slope.	Moderate where slope is 3 to 8 percent: low strength; shrink-swell. Moderate where slope is more than 8 percent: low strength; shrink-swell; slope.	Severe: frost action.
Rock land: Ro No interpretations made; properties too variable.				
Rock outcrop: Rp No interpretations made; properties too variable.				
Scholle: ScC	Moderate where slope is 3 to 8 percent: percs slowly.[1] Moderate where slope is more than 8 percent: percs slowly; slope.	Moderate where slope is 3 to 7 percent: seepage. Severe where slope is more than 7 percent: slope.	Moderate where slope is 3 to 8 percent: shrink-swell. Moderate where slope is more than 8 percent: shrink-swell; slope.	Moderate where slope is 3 to 8 percent: low strength; shrink-swell. Moderate where slope is more than 8 percent: low strength; shrink-swell; slope.
Shale outcrop. Mapped only with Utaline soils. Properties too variable to rate.				
Skyway Mapped only with Mayflower soils.	Severe where slope is 5 to 15 percent: depth to rock. Severe where solpe is more than 15 percent: depth to rock; slope.	Severe where slope is 5 to 7 percent: depth to rock; seepage. Severe where slope is more than 7 percent: depth to rock; seepage; slope.	Slight where slope is 5 to 8 percent. Moderate where slope is 8 to 15 percent: slope. Severe where slope is more than 15 percent: slope.	Severe where slope is 5 to 15 percent: frost action. Severe where slope is more than 15 percent: frost action; slope.
Splitro Mapped only with Miracle soils.	Severe where slope is 2 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Severe where slope is 2 to 7 percent: depth to rock. Severe where slope is more than 7 percent: depth to rock; slope.	Severe where slope is 2 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Severe where slope is 2 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.
Stony land: St No interpretations made; properties too variable.				
Uffens: UfC	Severe: percs slowly.	Moderate where slope is 3 to 7 percent: slope. Severe where slope is more than 7 percent: slope.	Moderate: frost action; low strength.	Moderate: shrink-swell; frost action; low strength.

properties of the soils—Continued

Degree and kind of limitations for—Continued	Suitability as source of—			Soil features affecting—	
Shallow excavations	Road fill	Sand	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments
Slight where slope is 3 to 8 percent. Moderate where slope is 8 to 15 percent: slope.	Poor: frost action.	Unsuited	Fair: too clayey	Seepage; slope	Hard to pack; low strength.
Moderate where slope is 3 to 8 percent: large stones. Moderate where slope is more than 8 percent: large stones; slope.	Fair: low strength; shrink-swell.	Unsuited	Poor: large stones; thin layer.	Seepage where slope is 3 to 7 percent. Seepage and slope where slope is more than 7 percent.	Compressible; low strength; piping.
Severe: depth to rock	Poor where slope is 5 to 25 percent: thin layer; frost action. Poor where slope is more than 25 percent: thin layer slope; frost action.	Poor	Good where slope is 5 to 8 percent. Fair where slope is 8 to 15 percent: slope. Poor where slope is more than 15 percent: slope.	Seepage; slope; depth to rock.	Thin layer.
Severe where slope is 2 to 15 percent: depth to rock. Severe where slope is more than 15 percent: depth to rock; slope.	Poor: depth to rock.	Unsuited	Poor: thin layer	Depth to rock; slope.	Depth to rock; thin layer.
Slight	Moderate: shrink-swell; frost action; low strength.	Unsuited	Poor: excess salt, excess alkali.	Slope	Piping; low strength; shrink-swell.

TABLE 4.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—			
	Septic tank absorption fields	Sewage lagoons	Dwellings without basements	Roads and streets
Unaweep: UnC	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.	Severe where slope is 3 to 7 percent: seepage. Severe where slope is more than 7 percent: seepage.	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.	Severe where slope is more than 3 percent: frost action.
Utaline: UoD, Us. No interpretations made for Shale outcrop part; properties too variable.	Slight where slope is 3 to 8 percent. Moderate where slope is 8 to 15 percent: slope. Severe where slope is more than 15 percent: slope.	Severe where slope is 3 to 7 percent: seepage. Severe where slope is more than 7 percent: seepage; slope.	Slight where slope is 3 to 8 percent. Moderate where slope is 8 to 15 percent: slope. Severe where slope is more than 15 percent: slope.	Slight where slope is 2 to 8 percent. Moderate where slope is 8 to 15 percent: slope. Severe where slope is more than 15 percent: slope.
Wet alluvial land: We	Severe: wetness; floods.	Severe: wetness; floods.	Severe: wetness; floods.	Severe: wetness; floods.
Witt. Mapped only with Gibbler soils.	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.	Moderate where slope is 3 to 7 percent: slope; seepage. Severe where slope is more than 7 percent: slope.	Slight where slope is 3 to 8 percent. Moderate where slope is more than 8 percent: slope.	Moderate where slope is 3 to 8 percent: low strength; shrink-swell. Moderate where slope is more than 8 percent: low strength; shrink-swell; slope.
Youngston: Yo	Slight[1]	Moderate where slope is 0 to 2 percent: seepage. Moderate where slope is more than 2 percent: seepage.	Moderate: low strength.	Severe: frost action.

[1] Pollution is a hazard in some places because the substratum is permeable.

lated to soil properties such as drainage, texture, total acidity, and electrical conductivity of the soil material. Corrosivity for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. A corrosivity rating of *low* means that there is a low probability of soil-induced corrosion damage. A rating of *high* means that there is a high probability of damage, so that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

Engineering interpretations

The estimated interpretations in table 4 are based on the engineering properties of soils shown in table 3, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Mesa County Area. Table 4 gives ratings that summarize the limitation or suitability of the soils for the listed purposes. It also lists those soil features not to be overlooked in the planning, installation, and maintenance of pond reservoir areas and dikes, levees, and embankments.

Soil limitations are indicated by the ratings slight, moderate, and severe. *Slight* means soil properties are generally favorable for the rated use, or in other words, limitations that are minor and easily overcome. *Moderate* means that some soil properties are not favorable but can be overcome or modified by special planning and design. *Severe* means soil properties are so unfavorable and so difficult to correct or overcome as to require major soil reclamation and special designs.

Soil suitability is rated by the terms *good, fair,* and *poor.* They have meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of the column headings in table 4.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from

properties of the soils—Continued

Degree and kind of limitations for—Continued	Suitability as source of—			Soil features affecting—	
Shallow excavations	Road fill	Sand	Topsoil	Pond reservoir areas	Dikes, levees, and other embankments
Slight where slope is 0 to 8 percent. Moderate where slope is more than 8 percent: slope.	Severe: frost action.	Poor	Good where slope is 3 to 8 percent. Fair where slope is more than 8 percent: slope.	Seepage; slope	Piping.
Severe where slope is 2 to 15 percent: small stones. Severe where slope is more than 15 percent: slope.	Good where slope is 3 to 15 percent. Fair where slope is more than 15 percent: slope.	Poor	Poor where slope is 3 to 15 percent: small stones. Poor where slope is more than 15 percent: small stones; slope.	Seepage; slope	Large stones.
Severe: wetness	Poor: wetness; floods.	Unsuited	Fair: wetness; floods.	Wetness; floods	Wetness.
Moderate: too clayey	Fair: low strength; shrink-swell.	Unsuited	Fair where slope is 3 to 8 percent: slope; too clayey. Fair where slope is more than 8 percent: too clayey; slope.	Seepage; slope	Low strength; piping: shrink-swell.
Slight	Poor: frost action.	Unsuited	Good	Seepage	Low strength.

a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor, and sides, or embankments, of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic matter, and slope, and if the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification and the amounts of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Dwellings without basements are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Roads and streets, as rated in table 4, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordi-

nary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet, as for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Soil properties that most affect design and construction of roads and streets are load supporting capacity and stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade. Road fill is soil material used in embankments for roads. The suitability ratings reflect (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and (2) the relative ease of excavating the material at borrow areas.

Sand is used in great quantities in many kinds of construction. The ratings in table 4 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the material, and neither do they indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or its response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is damage that will result at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Dikes, levees, and other embankments require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material in a soil are among factors that are unfavorable.

Formation and Classification of the Soils

In this section, the factors that affect the formation of soils are discussed. The soil series of the county are placed in the higher categories of soil classification, and these categories are defined.

Formation of the Soils

Soil is composed of mineral matter mixed with varying amounts of organic matter derived mostly from vegetation. The mineral matter is derived from parent material that has been weathered and broken down by the combined effect of climate, living organisms, and topography through long periods of time. Within short distances, the combination of these factors varies, and consequently the soils have different fertility, productivity, and physical and chemical characteristics.

Parent material

Many soils in the Mesa County Area formed in residuum that weathered from sandstone or shale. Some soils formed in alluvium that was derived from sandstone and shale deposited in the major valleys and on bordering uplands. Several soils formed in sandy wind-deposited materials. Soils that formed in weathered sandstone, such as those in the Nelman series, are generally sandy. The clay these soils contain was an impurity in the sandstone that was released by weathering. Soils that formed in shale, such as those in the Chipeta series, are clayey because clay is the basic constituent of shale. Soils that formed in mixed alluvium derived from sandstone and shale, such as those in the Loma series, are loamy. Some of the soils in the county have acquired excess salt and sodium from the parent material.

Climate

Climate is an active part of the formation of soils. It is determined mainly by temperature and precipitation. Erosion and alternate freezing and heating break rocks down into small fragments. The weathered material is further broken down by chemical reactions such as solution and hydration. In this county, precipitation ranges from about 8 to 24 inches. Soils of the Entisol order, such as those in the Persayo series, are in the driest and warmest areas of the county. Soils of the Mollisol order, such as those in the Mayflower series, are in the cooler, wetter parts.

Living organisms

Living organisms also are active in the formation of soils. Organic matter is the main source of the dark color in soils. Fungi and algae are among the earliest inhabitants of rock material, and they help break down the rock. As the rock weathers, grasses, shrubs, and trees are able to grow and support animal life.

The kinds of plants and animals present largely determine the kinds and amount of organic matter added to the soil and how this matter is incorporated with the mineral part of the soil. Roots, rodents, and insects penetrate the soil and influence its structure. Leaves, roots, and whole plants that stay in the surface layer are changed to humus by micro-organisms, chemicals, and insects.

The plants in Mesa County range from desert shrubs and grasses to ponderosa pine, juniper, and pinyon trees in the valleys, lower mountains, and foothills.

Spruce and fir trees are the main plants in the higher mountain areas. Common rodents are gophers, prairie dogs, badgers, rabbits, and marmots. Pebbles and stones on the surface of terraces and in many other areas have been dug up by burrowing rodents.

Topography

Topography, or relief, is determined by the resistance of bedrock to erosion by water and soil blowing. In the eroded uplands of the county, runoff water has carved deep valleys that have many branches into the original bedrock. The rugged relief contrasts sharply with the smooth low relief of the terraces and flood plains of the river valleys.

In the uplands the number and the distinctness of soil horizons decrease as slope increases. Steep soils that have rapid runoff have many characteristics similar to those of soils formed in arid climates. Level soils that receive runoff water from overlying areas have many of the characteristics of soils that formed in a humid climate. Examples of this pattern are the shallow Batterson soil that is steep and the deep Loma soil in swales and depressions. The Batterson soil has no B horizon, but the Loma soil has a B horizon 10 to 15 inches thick.

Time

The changes that take place in a soil over long periods give the soil distinct horizons, or layers, by which it can be recognized. The kind and arrangement of horizons are called soil morphology and can be described in terms of color, texture, structure, consistence, and thickness.

The length of time a soil has been forming is determined in part from the thickness of the A horizon, the content of organic matter and of clay, the depth to which soluble material is leached, and the form and distribution of calcium carbonate and gypsum in the soil.

Billings silty clay loam, a soil of the Entisol order, is an example of a young soil. It is on a flood plain adjacent to streams. The content of organic matter is not enough for an A horizon to form, there is no layer of clay accumulation, and little translocation of carbonates has occurred so that B2 and Cca horizons could form.

The Loma soils formed in parent material similar to, but much older than, that of Billings silty clay loam. Loma soils formed in alluvium on uplands and are in the Mollisol order. They contain enough organic matter to have a dark A horizon. Also, they have distinct clay accumulation in the B2t horizon, and very distinct accumulation of carbonates in the lower part of the subsoil and the substratum.

Classification of Soils

Soils are classified to show their significant characteristics. Classification helps to assemble knowledge about the soils, to see the relationship of one soil to another and to the whole environment, and to develop principles for understanding their behavior and response to manipulation. First through classification, and then through use of soil maps, knowledge of soils can be applied to specific fields and other tracts of land (*3, 4, 5*).

The narrow categories of classification, such as those used in detailed soil surveys, help to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes for study and comparison of large areas as countries and continents.

The system of soil classification currently used (*7*) was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available.

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. In table 5, the soil series of Mesa County Area are placed in categories of the current system. They are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Ent-i-sol).

SUBORDER. Each order is subdivided into suborders that are based primarily on those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging, or soil differences resulting from the climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order.

GREAT GROUP. Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark-colored surface horizons. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark-red and dark-brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder.

SUBGROUP. Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of sub-

TABLE 5.—*Classification of the soils*

Series	Family	Subgroup	Order
Avalon	Fine-loamy, mixed, mesic	Typic Calciorthids	Aridisols.
Bangston	Sandy, mixed	Typic Cryoborolls	Mollisols.
Bankard	Sandy, mixed, mesic	Ustic Torrifluvents	Entisols.
Batterson	Sandy, mixed, mesic	Lithic Ustic Torriorthents	Entisols.
Billings	Fine-silty, mixed, (calcareous), mesic	Typic Torrifluvents	Entisols.
Blackston	Loamy-skeletal, mixed, mesic	Typic Calciorthids	Aridisols.
Cebone	Fine, montmorillonitic	Boralfic Cryoborolls	Mollisols.
Chipeta	Clayey, mixed, (calcareous), mesic, shallow	Typic Torriorthents	Entisols.
Dominguez	Fine, montmorillonitic, mesic	Ustertic Camborthids	Aridisols.
Dwyer	Mixed, mesic	Ustic Torripsamments	Entisols.
Fruita	Fine-loamy, mixed, mesic	Typic Haplargids	Aridisols.
Gateway	Fine, montmorillonitic	Typic Cryoboralfs	Alfisols.
Gibbler	Fine, montmorillonitic, mesic	Ustollic Paleargids	Aridisols.
Glenberg	Coarse-loamy, mixed, (calcareous), mesic	Ustic Torrifluvents	Entisols.
Ildefonso	Loamy-skeletal, mixed, mesic	Ustollic Calciorthids	Aridisols.
Lazear	Loamy, mixed, (calcareous), mesic	Lithic Ustic Torriorthents	Entisols.
Loma	Fine, montmorillonitic, mesic	Aridic Argiustolls	Mollisols.
Mayflower	Fine, montmorillonitic	Argic Pachic Cryoborolls	Mollisols.
Miracle	Fine-loamy, mixed	Argic Cryoborolls	Mollisols.
Nelman	Coarse-loamy, mixed, (calcareous), mesic	Ustic Torriorthents	Entisols.
Owen Creek	Fine, montmorillonitic	Argic Cryoborolls	Mollisols.
Palma	Coarse-loamy, mixed, mesic	Ustollic Haplargids	Aridisols.
Persayo	Loamy, mixed, (calcareous), mesic, shallow	Typic Torriorthents	Entisols.
Potts	Fine-loamy, mixed, mesic	Ustollic Haplargids	Aridisols.
Scholle	Fine-loamy, mixed, mesic	Ustollic Haplargids	Aridisols.
Skyway	Coarse-loamy, mixed	Pachic Cryoborolls	Mollisols.
Splitro	Loamy, mixed	Lithic Cryoborolls	Mollisols.
Uffens	Fine-loamy, mixed, mesic	Typic Natrargids	Aridisols.
Unaweep	Coarse-loamy, mixed, mesic	Aridic Haplustolls	Mollisols.
Utaline	Loamy-skeletal, mixed, mesic	Typic Calciorthids	Aridisols.
Witt	Fine-silty, mixed, mesic	Ustollic Haplargids	Aridisols.
Youngston	Fine-loamy, mixed, (calcareous), mesic	Typic Torrifluvents	Entisols.

groups are derived by placing one or more adjectives before the name of the great group.

FAMILY. Soil families are separated within a subgroup primarily on the basis of properties important to the growth of plants or on the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reactions, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentiae.

General Nature of the Area

Mesa County is in the Canyon Lands and Uinta Basin sections of the Colorado Plateau physiographic province. The major physiographic features in the area are the Grand Valley, the Little Book Cliffs, Grand Mesa, Plateau Valley, the Uncompahgre Plateau, and the Dolores River Valley. The high escarpment formed by the Little Book Cliffs and the west end of Grand Mesa extends from northwest to southeast across the middle of the county and marks the northern boundary of the Canyon Lands section and the southern boundary of the Uinta Basin section. Total relief within the county is about 6,900 feet. Altitude ranges from about 4,300 feet along the Colorado River at the west edge of the county to 11,234 feet at Leon Peak on Grand Mesa.

Mesa County is drained by the Colorado River and its tributaries. The Colorado River enters the county along the northern edge near the town of De Beque and within a few miles enters the deep De Beque Canyon, which cuts through the plateau at the eastern end of the Little Book Cliffs. The Colorado River emerges from De Beque Canyon just above the town of Palisade and crosses the Grand Valley for a distance of about 13 miles to the city of Grand Junction, where it is joined by the Gunnison River. The Colorado then turns abruptly northwestward and follows the southern margin of the Grand Valley for about 18 miles. Below Fruita it leaves the Grand Valley and cuts across the northern end of the Uncompahgre Plateau.

The southeastern and east-central parts of Mesa County are drained by the Gunnison River and its tributaries. Most of the northeastern part of the county is drained by Plateau Creek, which joins the Colorado River in De Beque Canyon. The southwestern part of the county is drained by the Dolores River and the Little Dolores River and their tributaries. Both of these streams join the Colorado River in Utah several miles west of the Colorado State line.

The Grand Mesa National Forest, though not in the Mesa County Area, is close enough to be of economic and recreational value. This forest is on Grand Mesa, a high plateau about 5,000 feet above the Grand Valley. The National Forest covers 679,804 acres and includes 225 reservoirs and natural lakes that supply Grand Junction, Fruita, Palisade, and other towns with ex-

cellent drinking water and some water for irrigation.

Ranchers can get permits from the government to graze livestock in the national forest. Sportsmen have access to 166 miles of streams and 60 lakes.

The Mesa County Area was Ute Indian territory until 1881. In that year immigrants entered the Grand Valley. The townsite for Grand Junction was established on September 26, 1881. On February 14, 1883 the area that now makes up Mesa County was taken from the western part of Gunnison County and organized as a political unit.

The farming development of the Grand Valley began with the completion of the first system of irrigation canals in 1885. By 1890, the population had increased to 4,260, and by 1900 to 9,267. The settlers came largely from Kansas, Nebraska, Missouri, other Central States, and Texas.

Grand Junction, population 20,840, is the county seat and largest town. Mesa County had a population of 55,287 in 1972.

Climate

The Mesa County Area has a rather wide range of climate. In the desert part, average annual precipitation ranges from 8 to 10 inches; summers are hot, winters are moderate, and the frost-free season ranges to 175 days. In the foothills, average annual precipitation ranges from 10 to 16 inches; summers are warm, winters are cool, and the frost-free season ranges from 100 to 125 days. In the mountains and Subalpine area, annual precipitation ranges from 16 to 24 inches and is mostly snow. These areas have cool summers and cold winters and a frost-free season that ranges from 35 to 75 days in the Subalpine area and from 75 to 125 days in the lower mountains.

Temperature generally decreases with increasing elevation, but the temperature at night is often lower along river valleys than at the higher places that have more cold air movement. Daytime temperatures vary 2° to 5° for each thousand feet difference in elevation and are largely affected by local terrain.

A summary of temperature and precipitation data from the Colorado National Monument station is given in table 6. Table 7 gives the probabilities of the last freezing temperatures in spring and the first in fall at the same station.

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[4] Tables 6 and 7 were prepared by J. W. BERRY, climatologist for Colorado, National Weather Service, U.S. Department of Commerce.

Glossary

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Area reclaim. Borrow areas are difficult to reclaim, and revegetation and erosion control on these areas are extremely difficult.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Channery soil. A soil that contains thin, flat fragments of sandstone, limestone, or schist, as much as 6 inches in length along the longer axis. A single piece is called a fragment.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Climax vegetation. The stabilized plant community on a particular site; it reproduces itself and does not change so long as the environment does not change.

Complex slopes. Short and irregular slopes. Planning and construction of terraces, diversions, and other water-control measures are difficult.

Compressible. The soil is relatively soft and decreases excessively in volume when a load is applied.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Corrosive. The soil has high potential for causing uncoated steel to corrode or concrete to deteriorate.

Cutbanks cave. Walls of cuts are not stable. The soil sloughs easily.

Deferred grazing. The practice of delaying grazing until range

TABLE 6.—*Temperature and precipitation data*

Month	Temperature				Precipitation				
			Two years in 10 have at least 4 days with—			One year in 10 have—		Average number of days with snow cover of 0.1 inch or more	Average depth of snow on days with snow cover of 0.1 inch or more
	Average daily maximum	Average daily minimum	Maximum temperatures equal to or higher than—	Minimum temperatures equal to or lower than—	Average total	Less than—	More than—		
	°F	°F	°F	°F	In	In	In		In
January	37	19	48	4	0.95	0.3	1.8	14	5
February	42	23	54	9	.80	.4	1.5	9	7
March	51	29	65	16	1.01	.2	1.9	3	3
April	63	39	77	26	.93	.4	1.8	(1)	2
May	75	48	86	35	.73	.3	1.4	0	0
June	85	57	96	43	.69	.1	1.5	0	0
July	92	64	98	56	.73	.3	1.3	0	0
August	88	61	97	53	1.56	.1	2.4	0	0
September	80	54	92	41	.86	.1	2.1	0	0
October	67	43	79	31	1.10	.1	2.4	(1)	2
November	49	29	63	18	.81	.2	1.7	2	3
December	39	22	51	8	.70	.2	1.5	10	4
Year	64	41	[2] 99	[3] 0	10.87	7.0	15.0	38	5

[1] Less than one-half day. [2] Average annual highest temperature. [3] Average annual lowest temperature.

plants have reached a definite stage of growth, in order to increase the vigor of the forage and to allow the desirable plants to produce seed. Contrasts with continuous grazing and rotation grazing.

Depth to rock. Bedrock is so near the surface that it affects specified use of the soil.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low available water capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Excess alkali. Exchangeable sodium imparts poor physical properties that restrict the growth of plants.

Excess fines. The soil contains too much silt and clay for use as gravel or sand in construction.

Excess lime. The amount of carbonates in the soil is so high that it restricts the growth of some plants.

Excess salt. The amount of soluble salt in the soil is so high that it restricts the growth of most plants.

Fast intake. Water infiltrates rapidly into the soil.

Favorable. Features of the soil are favorable for the intended use.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has been allowed to drain away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Frost action. Freezing and thawing may damage structures.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rains. The distinction between gully and rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by normal tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage. V-shaped gullies result if the material is more difficult to erode with depth; whereas U-shaped gullies result if the lower material is more easily eroded than that above it.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumula-

TABLE 7.—*Probability of last freezing temperatures in spring and first in fall*

[Elevation 5,780 feet]

Probability	Dates for given probability and temperature				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	March 28	April 3	April 16	May 5	May 17
2 years in 10 later than	March 22	March 29	April 10	April 29	May 11
5 years in 10 later than	March 11	March 17	March 29	April 18	April 30
Fall:					
1 year in 10 earlier than	November 8	November 2	October 26	October 12	October 4
2 years in 10 earlier than	November 14	November 8	November 1	October 18	October 10
5 years in 10 earlier than	November 25	November 19	November 12	October 29	October 21

tion of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Basin.—Water is applied rapidly to relatively level plots surrounded by levees or dikes.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops, or in orchards, to confine the flow of water to one direction.

Furrow.—Water is applied in small ditches made by cultivation implements used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Irrigation water, released at high points, flows onto the field without controlled distribution.

Large stones. Rock fragments 10 inches or more across affect the specified use.

Low strength. The soil has inadequate strength to support loads.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Percs slowly. Water moves through the soil slowly, affecting the specified use.

Permafrost. The soil contains frozen layers throughout the year.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

pH value. A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Piping. The soil is susceptible to the formation of tunnels or pipelike cavities by moving water.

Pitting. The soil is susceptible to the formation of pits caused by the melting of ground ice when the plant cover is removed.

Poor outlets. Surface or subsurface drainage outlets are difficult or expensive to install.

Range condition. The state of health or productivity of both soil and forage in a given range, in terms of what productivity could or should be under normal climate and the best practical management. Condition classes generally recognized are—*excellent, good, fair,* and *poor.* The classification is based on the percentage of original, or climax, vegetation on the site, as compared to what ought to grow on it if management were good.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Rooting depth. A layer that greatly restricts the downward rooting of plants occurs at a shallow depth.

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Seepage. Water moves through the soil so quickly that it affects the specified use.

Shrink-swell. The soil expands on wetting and shrinks on dry-

ing, which may cause damage to roads, dams, building foundations, or other structures.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slow intake. Water infiltrates slowly into the soil.

Slow refill. Ponds fill slowly because the permeability of the soil is restricted.

Small stones. Rock fragments that are less than 10 inches across may affect the specified use.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles) adhering together without any regular cleavage, as in many claypans and hardpans).

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Thin layer. Suitable soil material is not thick enough for use as borrow material or topsoil.

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Unstable fill. Banks of fill are likely to cave in or slough.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a capability unit or range site, read the introduction to the section it is in for general information about its management.

Map symbol	Mapping unit	Page	Capability unit Symbol	Page	Range site Name	Page
Ad	Alluvial land	4	VIIIw-1	23	--	--
AvA	Avalon loam, 0 to 3 percent slopes	5	VIe-1	22	Loamy Salt Desert	25
AvC	Avalon loam, 3 to 12 percent slopes	5	VIe-1	22	Loamy Salt Desert	25
Ba	Badland	5	VIIIe-1	23	--	--
Bd	Bankard loamy sand	6	VIIw-1	23	Salt Flats	24
BrC	Batterson-Rock outcrop complex, 3 to 12 percent slopes	6	VIIe-1	23	--	--
Bs	Billings silty clay loam	7	IIs-1 irrigated	22	Salt Flats	24
			VIIs-2 nonirrigated	23		
BtD	Blackston stony loam, 3 to 25 percent slopes	7	VIe-1	22	Loamy Salt Desert	25
ChD	Chipeta silty clay, 3 to 25 percent slopes	8	VIIe-1	23	Clayey Salt Desert	24
DoC	Dominguez clay loam, 3 to 12 percent slopes	9	VIe-2	22	Clayey Foothills	26
DwC	Dwyer loamy sand, 3 to 12 percent slopes	9	VIe-2	22	Sandy Foothills	26
FaC	Fruita-Avalon association, undulating	9	VIe-1	22	Loamy Salt Desert	25
GcE	Gateway-Cebone-Bangston association, steep	11	VIe-3	23	--	--
GcF	Gateway-Cebone-Bangston association, very steep	11	VIIe-2	23	--	--
GeC	Gibbler-Witt association, undulating	11	VIe-2	22	Loamy Foothills	26
GlA	Glenberg sandy loam, 0 to 3 percent slopes	12	IIe-1 irrigated	22	Sandy Foothills	26
			VIe-2 nonirrigated	22		
GlB	Glenberg sandy loam, 3 to 8 percent slopes	12	VIe-2	22	Sandy Foothills	26
Gu	Gullied land	12	VIIIe-1	23	--	--
IdC	Ildefonso cobbly sandy loam, 3 to 12 percent slopes	12	VIIe-1	23	Stony Salt Desert	25
LkE	Lazear-Rock outcrop complex, 3 to 30 percent slopes	13	--	--	--	--
	Lazear gravelly loam	--	VIIe-1	23	Loamy Salt Desert	25
	Rock outcrop	--	--	--	--	--
Lo	Loma loam	13	VIe-2	22	Loamy Foothills	26
MkD	Mayflower-Skyway association, rolling	14	VIe-2	22	Subalpine Loam	28
MpC	Miracle-Splitro association, undulating	14	VIe-2	22	Mountain Loam	27
NeC	Nelman sandy loam, 3 to 12 percent slopes	15	VIe-1	22	Loamy Salt Desert	25
NlC	Nelman-Lazear sandy loams, 3 to 12 percent slopes	15	VIe-1	22	Loamy Salt Desert	25
OcC	Owen Creek-Miracle complex, 3 to 12 percent slopes	15	VIe-2	22	Mountain Loam	27
OcE	Owen Creek-Miracle complex, 12 to 30 percent slopes	15	VIe-2	22	Mountain Loam	27
PaC	Palma sandy loam, 3 to 12 percent slopes	16	IVe-1 irrigated	22	Loamy Foothills	26
			VIe-2 nonirrigated	22		
PeD	Persayo silt loam, 3 to 25 percent slopes	16	VIIe-1	23	Silty Salt Desert	24
PoC	Potts sandy loam, 3 to 12 percent slopes	17	IVe-1 irrigated	22	Loamy Foothills	26
			VIe-2 nonirrigated	22		
Ro	Rock land	17	VIIs-1	23	--	--
Rp	Rock outcrop	17	VIIIs-1	23	--	--
ScC	Scholle stony loam, 3 to 12 percent slopes	17	VIe-2	22	Loamy Foothills	26
St	Stony land	18	VIIs-1	23	--	--
UfC	Uffens loam, 3 to 12 percent slopes	19	VIIe-1	23	Salt Flats	24
UnC	Unaweep sandy loam, 3 to 12 percent slopes	19	IVe-1 irrigated	22	Loamy Foothills	26
			VIe-2 nonirrigated	22		
UoD	Utaline stony loam, 3 to 25 percent slopes	20	VIIe-1	23	Stony Salt Desert	25
Us	Utaline-Shale outcrop complex	20	--	--	--	--
	Utaline stony loam	--	VIIe-1	23	Stony Salt Desert	25
	Shale outcrop	--	--	--	--	--
We	Wet alluvial land	20	Vw-1	22	Mountain Meadow	28
Yo	Youngston loam	21	VIe-1	22	Loamy Salt Desert	25

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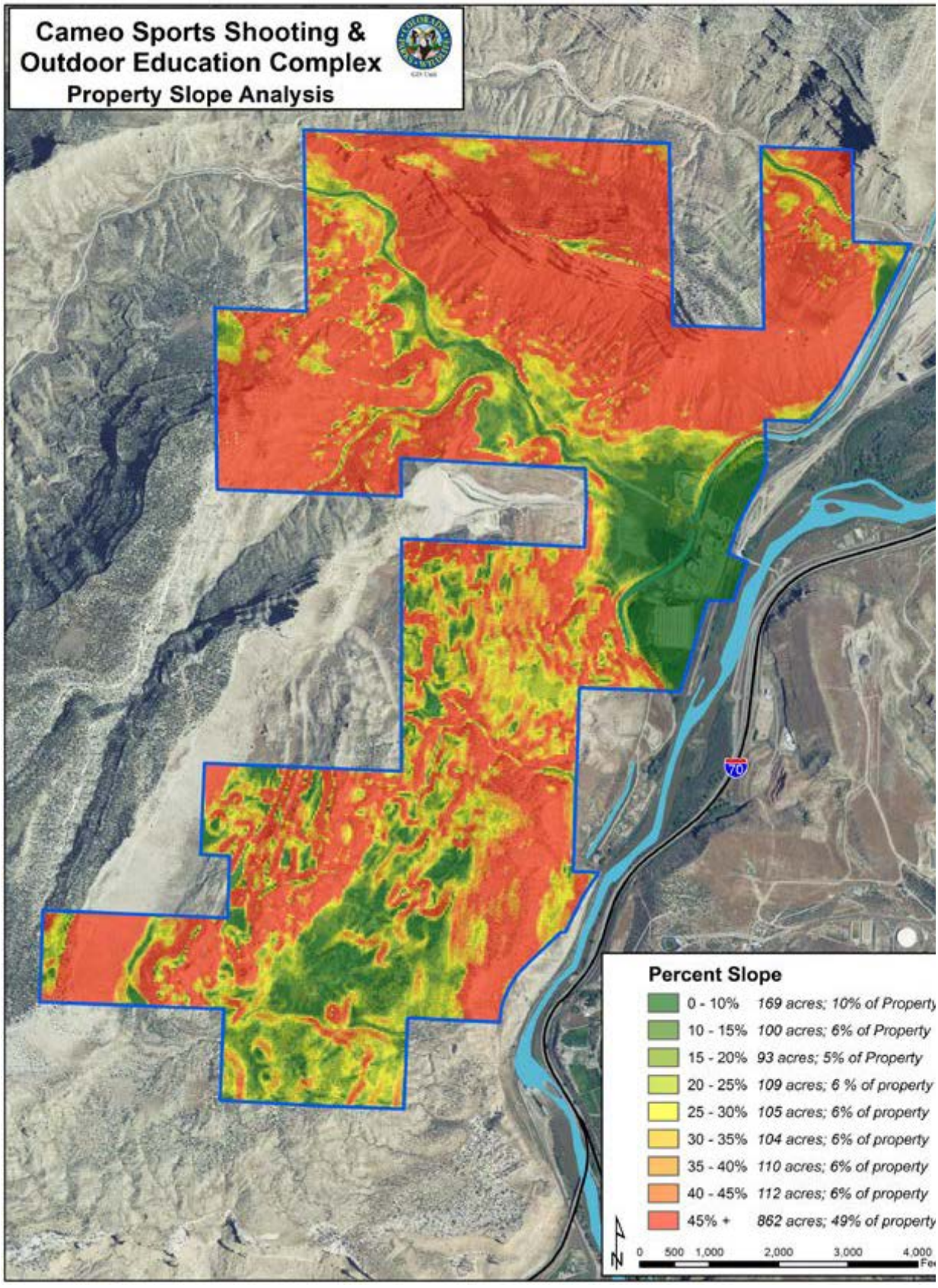
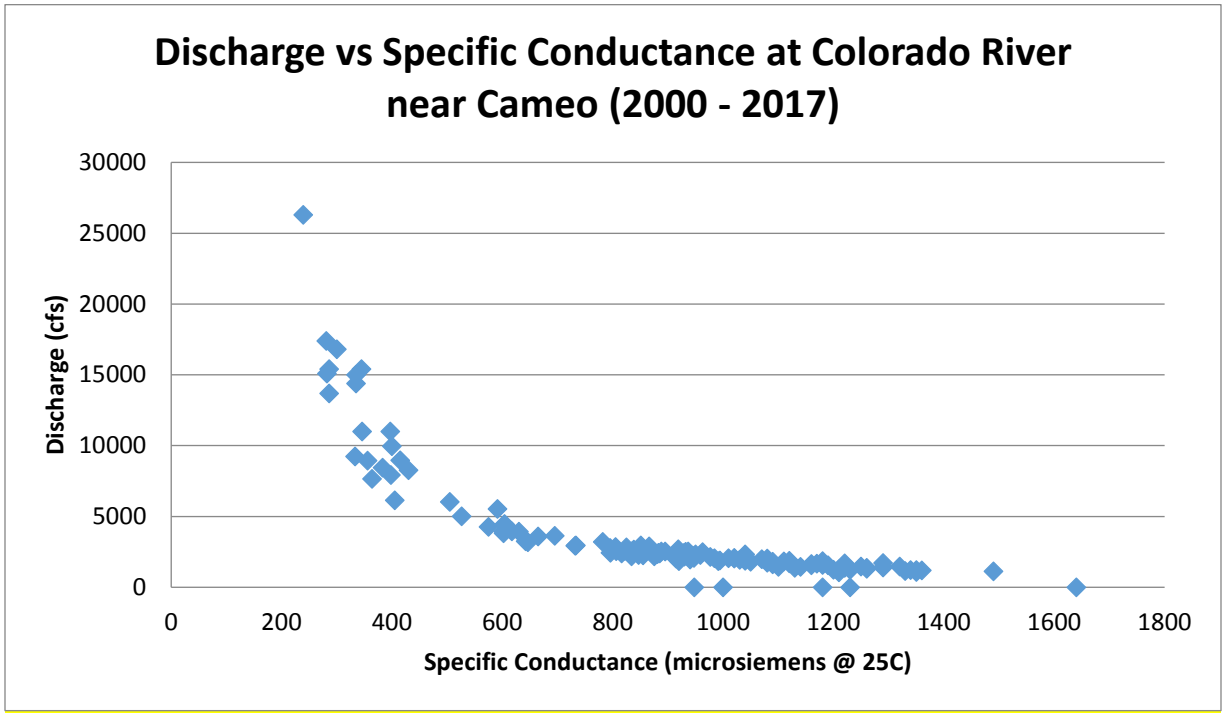
APPENDIX H -


Cameo Sports Shooting &
Outdoor Education Complex
Property Slope Analysis
70
Percent Slope
0 - 10% 169 acres; 10% of Property
10 - 15% 100 acres; 6% of Property
15 - 20% 93 acres; 5% of Property
20 - 25% 109 acres; 6 % of property
25 - 30% 105 acres; 6% of property
30 - 35% 104 acres; 6% of property
35 - 40% 110 acres; 6% of property
40 - 45% 112 acres; 6% of property
45% + 862 acres; 49% of property
0 500 1,000 2,000 3,000 4,000

APPENDIX I –

Plot from the USGS gage 'Colorado River below Grand Valley Diversion' (#0916150) showing inverse relation between discharge and specific conductance, reflecting the dilution effects of high flows on surface water quality in the receiving water just below the mouth of Coal Creek.7



APPENDIX J –

Photos of Vegetation Mosaics at the CAMEO Project Site.

Colorado Natural Heritage Program

Connecting Conservation and Science

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Ecological Systems of Colorado

Ecological systems are dynamic assemblages or complexes of plant and/or animal communities that 1) occur together on the landscape; 2) are tied together by similar ecological processes, underlying abiotic environmental factors or gradients; and 3) form a readily identifiable unit on the ground. These systems provide a coarser level unit than plant associations and alliances as defined under the International Vegetation Classification standard, and are more easily identified on the ground.

The descriptions and summarized viability guidelines presented here are intended to serve as a tool for conservation and management planning by providing a context for conservation and management (i.e., what systems do we have in Colorado), and by providing easy access to ranking and evaluation criteria for key ecological attributes of each system (i.e., what is the condition of our systems).

System descriptions and viability guidelines are based on materials compiled by NatureServe or developed by the Colorado Natural Heritage Program. Funding for the development of these documents was provided in part by the Bureau of Land Management, The Nature Conservancy, and the USDA Forest Service. Maps were produced using the Southwest Regional Gap Analysis Project landcover dataset. Please note that the extent of each system is exaggerated for display at a statewide scale.

Viability specification tables in these documents summarize the factors that contribute to an overall element occurrence (EO) ranking. The estimated viability ranks are: A - excellent, B - good, C - fair, or D - poor. The three primary rank factors (size, condition, and landscape context) are shown in relative order of importance. These factors reflect the present status, or quality of an occurrence and are used as the basis for estimating its long-term viability:

Size + Condition + Landscape Context ⇒ Estimated Viability ≈ EO Rank

For ecological systems, the term "viability" is used loosely, since systems are comprised of many separate communities and species, each with their own viability. The viability of an ecological system is considered to be the sum of the viability or persistence of the component communities and their ecological processes. More directly, the ranks usually reflect the degree of negative anthropogenic impact to a community (i.e., the degree to which people have directly or indirectly adversely impacted community composition, structure, and/or function, including alteration of natural disturbance processes). Occurrences of adequate size with relatively few impacts would generally be ranked "A", "B", or "C" (at least "fair" viability, with a high probability of long-term persistence), and those with significant degradation would be ranked "D" ("poor" viability, requiring significant restoration work to enable persistence of the occurrence).

Citation for these documents:

Colorado Natural Heritage Program. 2005. Ecological System Descriptions and Viability Guidelines for Colorado. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Viewable List of Ecological System Documents

Central Mixedgrass Prairie (PDF 635 kb)

Colorado Plateau Blackbrush-Mormon-tea Shrubland (Not Yet Available)

Colorado Plateau Hanging Garden (PDF 676 kb)

Colorado Plateau Mixed Bedrock Canyon and Tableland (PDF 1.09 mb)

Colorado Plateau Mixed Low Sagebrush Shrubland (Not Yet Available)

Colorado Plateau Pinyon-Juniper Shrubland (Not Yet Available)

Related Topics

Conservation Status Handbook (Tracking Lists)
Data Dictionaries
Maps & Map Layers
Reports & Documents

Colorado Plateau Pinyon-Juniper Woodland (PDF 907 kb)

Inter-Mountain Basins Active and Stabilized Dunes (Not Yet Available)

Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland (Not Yet Available)

Inter-Mountain Basins Big Sagebrush Shrubland (PDF 827 kb)

Inter-Mountain Basins Big Sagebrush Steppe (Not Yet Available)

Inter-Mountain Basins Greasewood Flat (PDF 813 kb)

Inter-Mountain Basins Interdunal Swale Wetland (Not Yet Available)

Inter-Mountain Basins Juniper Savanna (PDF 965 kb)

Inter-Mountain Basins Mat Saltbush Shrubland (PDF 784 kb)

Inter-Mountain Basins Mixed Salt Desert Scrub (PDF 703 kb)

Inter-Mountain Basins Montane Sagebrush Steppe (PDF 1.41 mb)

Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland (Not Yet Available)

Inter-Mountain Basins Playa (Not Yet Available)

Inter-Mountain Basins Semi-Desert Grassland (PDF 826 kb)

Inter-Mountain Basins Semi-Desert Shrub-Steppe (PDF 513 kb)

Inter-Mountain Basins Shale Badland (PDF 941 kb)

Inter-Mountain Basins Wash (Not Yet Available)

North American Alpine Ice Field (Not Yet Available)

North American Arid West Emergent Marsh (PDF 1.21 mb)

Northern Rocky Mountain Avalanche Chute Shrubland (Not Yet Available)

Rocky Mountain Alpine Bedrock and Scree (Not Yet Available)

Rocky Mountain Alpine Dwarf-Shrubland (Not Yet Available)

Rocky Mountain Alpine Fell-Field (Not Yet Available)

Rocky Mountain Alpine-Montane Wet Meadow (PDF 1.81 mb)

Rocky Mountain Aspen Forest and Woodland (PDF 1.03 mb)

Rocky Mountain Cliff, Canyon and Massive Bedrock (PDF 592 kb)

Rocky Mountain Dry Tundra (Not Yet Available)

Rocky Mountain Dry-Mesic and Mesic Montane Mixed Conifer Forest and Woodland (PDF 648 kb)

Rocky Mountain Foothill Limber Pine-Juniper Woodland (PDF 568 kb)

Rocky Mountain Gambel Oak-Mixed Montane Shrubland (PDF 921 kb)

Rocky Mountain Lodgepole Pine Forest (PDF 943 kb)

Rocky Mountain Lower Montane Riparian Woodland and Shrubland (PDF 920 kb)

Rocky Mountain Lower Montane-Foothill Shrubland (PDF 0.99 mb)

Rocky Mountain Ponderosa Pine Savanna (Not Yet Available)

Rocky Mountain Subalpine Dry-Mesic and Mesic Spruce-Fir Forest and Woodland (PDF 970 kb)

Rocky Mountain Subalpine Mesic Meadow (Not Yet Available)

Rocky Mountain Subalpine-Montane Fen (Not Yet Available)

Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland (PDF 746 kb)

Rocky Mountain Subalpine-Montane Riparian Shrubland (PDF 919 kb)

Rocky Mountain Subalpine-Montane Riparian Woodland (PDF 1.31 mb)

Southern Rocky Mountain Juniper Woodland and Savanna (PDF 827 kb)

Southern Rocky Mountain Montane-Subalpine Grassland (235 kb)

Southern Rocky Mountain Pinyon-Juniper Woodland (PDF 509 kb)

Southern Rocky Mountain Ponderosa Pine Woodland (PDF 1.11 mb)

Southwestern Great Plains Canyon (PDF 703 kb)

Western Great Plains Cliff, Outcrop, and Shale Barren(PDF 821 kb)

Western Great Plains Closed Depression Wetland (PDF 596 kb)

Western Great Plains Big River Floodplain (PDF 448 kb)

Western Great Plains Foothill and Piedmont Grassland (PDF 966 kb)

Western Great Plains Riparian Woodland, Shrubland and Herbaceous(PDF 785 kb)

Western Great Plains Saline Depression Wetland (Not Yet Available)

Western Great Plains Sand Prairie (Not Yet Available)

Western Great Plains Sandhill Shrubland (PDF 943 kb)

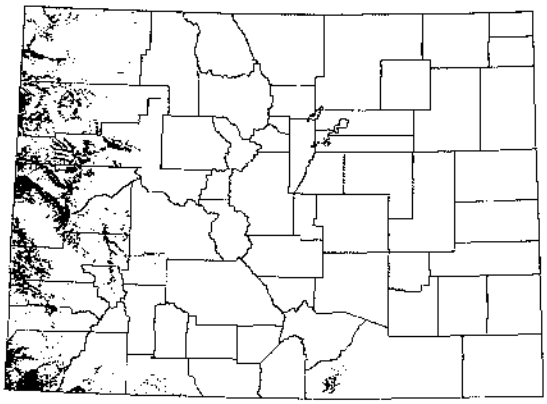
Western Great Plains Shortgrass Prairie(PDF 900 kb)

Western Great Plains Tallgrass Prairie (Not Yet Available)

Wyoming Basins Low Sagebrush Shrubland (Not Yet Available)

COLORADO PLATEAU MIXED BEDROCK CANYON AND TABLELAND

P. Lyon



extent exaggerated for display

CERCOCARPUS INTRICATUS SPARSELY VEGETATED ALLIANCE
Cercocarpus intricatus Slickrock Sparse Vegetation
JUNIPERUS OSTEOSPERMA WOODLAND ALLIANCE
Juniperus osteosperma / Artemisia nova / Rock Woodland
Juniperus osteosperma / Cercocarpus intricatus Woodland
PINUS EDULIS - (JUNIPERUS SPP.) WOODLAND ALLIANCE
Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus Woodland

Overview: The distribution of this ecological system is centered on the Colorado Plateau, where it is comprised of barren and sparsely vegetated landscapes (generally <10% plant cover) of steep cliff faces, narrow canyons, and open tablelands of predominantly sedimentary rocks, such as sandstone, shale, and limestone. Some eroding shale layers similar to Inter-Mountain Basins Shale Badland may be interbedded between the harder rocks. The vegetation is characterized by very open tree canopy or scattered trees and shrubs with a sparse herbaceous layer. Common species includes *Pinus edulis, Pinus ponderosa, Juniperus* spp., *Cercocarpus intricatus*, and other short-shrub and herbaceous species, utilizing moisture from cracks and pockets where soil accumulates.

Characteristic species: For the most part, this system is sparsely vegetated. Small patches of scattered trees and shrubs may occur. These small vegetated patches are usually dominated by conifers, and may include *Abies concolor, Juniperus osteosperma, Picea pungens, Pinus flexilis, Pinus longaeva, Pinus ponderosa*, and *Pseudotsuga menziesii*. If a shrub layer exists it may include *Acer glabrum, Amelanchier utahensis, Arctostaphylos patula, Ceanothus martinii, Cercocarpus montanus, Cercocarpus intricatus, Juniperus communis, Mahonia repens, Purshia tridentata, Ribes cereum*, and *Gutierrezia sarothrae*. Grasses and forbs, if present, may include *Astragalus kentrophyta, Clematis columbiana, Leymus salinus, Achnatherum hymenoides*, and *Linum kingii*.

Environment: This system includes steep cliff faces, narrow canyons, and open tablelands of predominantly sedimentary rocks, such as sandstone, shale, and limestone. Often 90% of the exposed surface consists of barren rock. It also includes areas of fixed bedrock forming the vertical or near-vertical parts on the plateau faces. The rocks forming such areas are predominantly limestone-capped plateaus. These highly erodible areas are generally too steep to allow any significant soil development. These areas are unstable and rocks are frequently rolling down onto the talus slopes below (often forming Inter-Mountain Basins Shale Badland). Scattered plants maintain a precarious foothold in the crevices of the rocks. Knolls may form at the base of the cliffs.

This ecological system also includes sandstone and shale escarpments, such as the scenic cliffs of the East Tavaputs area (the Book Cliffs). The rocks forming this escarpment are mostly sandstone

and shale with some limestone and marlstone. The larger drainages such as East Fork Parachute Creek plunge several hundred feet at this escarpment, creating scenic and lush hanging gardens. Many of these escarpments are over 1,000 feet in height and provide excellent habitat for cliff-nesting birds such as peregrine falcons and golden eagles.

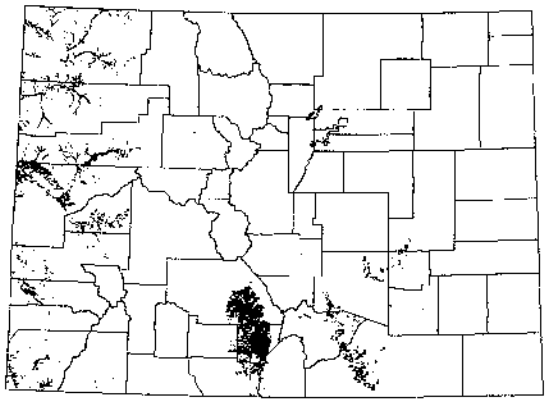
Dynamics: This ecological system has a naturally high rate of erosion. Freeze-thaw cycles are most pronounced on south-facing slopes. Soil development is limited. Infiltration rates are low and runoff high. Fires are infrequent and not an important ecological process.

S. Kettler

Rank:	A	B	C	D
① CONDITION				
Community structure	Dominated by native species.		Unnatural erosion, compaction, and altered species composition is usually noticeable.	
Natural processes (landslides, rockfalls, etc.)	Can occur on a natural time frame.		Present.	
Non-native species	Absent or < 1% cover.	May be present, but <3% cover.	Usually present, but not dominant except in small patches.	Present.
Anthropogenic disturbance	Fragmentation from roads or human development is non-existent or only on the edge of the occurrence. Breeding and roosting of cliff-nesting birds is not disrupted.	Fragmentation form roads or human development, if present, is limited to a small area of less than 0.5% of the occurrence.	Fragmentation from roads or human development (e.g., oil and gas) are frequent enough to cause an increase in non-native plants.	Greater than 30% of occurrence.
② SIZE				
Acres	>2,000	1,000-2,000	100-1,000	< 100
③ LANDSCAPE CONTEXT				
Connectivity	Highly connected.	Moderately connected.	Moderately fragmented.	Highly fragmented.
Surrounding land	Largely intact natural vegetation, with species interactions and natural processes occurring across communities.	Moderately intact natural vegetation, with species interactions and natural processes occurring across many communities; landscape includes partially disturbed natural or semi-natural communities, some of it not high quality due to overgrazing or recent logging.	Largely a combination of cultural and natural vegetation, with barriers between species interactions and natural processes across natural communities; occurrence is surrounded by a mix of intensive agriculture and adjacent forest lots (total area no smaller than ten times the minimum "C"-rated size).	Entirely, or almost entirely, surrounded by agricultural or urban land use; occurrence is at best buffered on one side by natural communities.

INTER-MOUNTAIN BASINS GREASEWOOD FLAT

S. Spackman



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DISTICHLIS SPICATA INTERMITTENTLY FLOODED HERBACEOUS ALLIANCE
Distichlis spicata - (Scirpus nevadensis) Herbaceous Vegetation
Distichlis spicata Herbaceous Vegetation
ELEOCHARIS PALUSTRIS SEASONALLY FLOODED HERBACEOUS ALLIANCE
Eleocharis palustris Herbaceous Vegetation
LEYMUS CINEREUS HERBACEOUS ALLIANCE
Leymus cinereus Herbaceous Vegetation
PUCCINELLIA NUTTALLIANA INTERMITTENTLY FLOODED HERBACEOUS ALLIANCE
Puccinellia nuttalliana Herbaceous Vegetation
SALICORNIA RUBRA SEASONALLY FLOODED HERBACEOUS ALLIANCE
Salicornia rubra Herbaceous Vegetation
SARCOBATUS VERMICULATUS INTERMITTENTLY FLOODED SHRUBLAND ALLIANCE
Sarcobatus vermiculatus - Artemisia tridentata Shrubland
Sarcobatus vermiculatus / Distichlis spicata Shrubland
Sarcobatus vermiculatus / Suaeda moquinii Shrubland
Sarcobatus vermiculatus Shrubland
SARCOBATUS VERMICULATUS INTERMITTENTLY FLOODED SPARSELY VEGETATED ALLIANCE
Sarcobatus vermiculatus / Juncus balticus Sparse Vegetation
Sarcobatus vermiculatus / Sporobolus airoides Sparse Vegetation
SARCOBATUS VERMICULATUS SHRUBLAND ALLIANCE
Sarcobatus vermiculatus / Bouteloua gracilis Shrubland
SPOROBOLUS AIROIDES HERBACEOUS ALLIANCE
Sporobolus airoides Southern Plains Herbaceous Vegetation
SPOROBOLUS AIROIDES INTERMITTENTLY FLOODED HERBACEOUS ALLIANCE
Sporobolus airoides - Distichlis spicata Herbaceous Vegetation

Overview: The Greasewood Flats ecological system occurs throughout much of the western U.S. in intermountain basins and extends onto the western Great Plains. In eastern Colorado, occurrences are primarily in the southwestern portion of plains. Large occurrences are also found in the lower elevations of Colorado's western valleys and throughout much of the San Luis Valley. Greasewood flats are large patch systems confined to specific environments defined by hydrologic regime, soil salinity and soil texture.

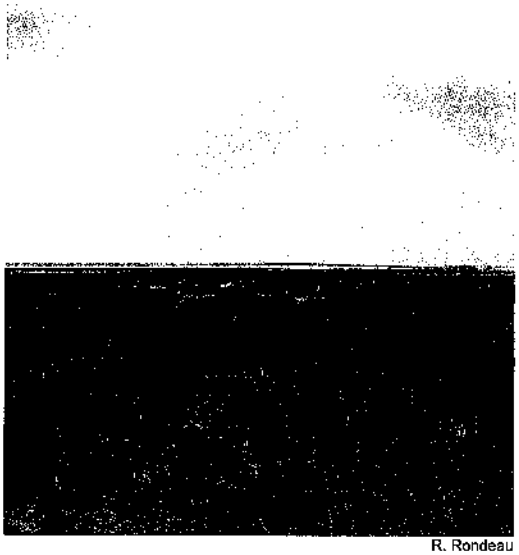
Characteristic species: This ecological system usually occurs as a mosaic of multiple communities, with open to moderately dense shrublands dominated or codominated by *Sarcobatus vermiculatus*. *Atriplex canescens, Atriplex confertifolia, Chrysothamnus nauseosus, Cylindropuntia candelabra,* or *Krascheninnikovia lanata* may be present to codominant. The herbaceous layer, if present, is usually dominated by graminoids such as *Sporobolus arioides, Distichlis spicata,* and *Bouteloua gracilis*. Small patches of *Sporobolus airoides, Distichlis spicata* (where water remains ponded the longest), or *Eleocharis palustris* herbaceous types may be found within the shrubland system.

Environment: Greasewood flats are typically found near drainages on stream terraces and flats, on alluvial fans along streams or arroyos, or they may form rings around playas. Sites usually have saline soils, a shallow water table and flood intermittently, but remain dry for most of the growing season.

Dynamics: Because greasewood flats are tightly associated with saline soils and groundwater that is near the surface, the primary ecological process that maintains greasewood flats is groundwater recharge, rather than surface water. *Sarcobatus vermiculatus* is often found on sites with high water tables that are intermittently flooded. Groundwater flows and depth are one of the most important driving factors in maintaining this system. *Sarcobatus vermiculatus*, like many facultative halophytes, is tolerant of alkaline and saline soil conditions that allow the species to occur in sites with less interspecific competition (Ungar et al. 1969, Bransen et al. 1976). The shrub also occurs on extremely arid non-saline sites.

Although most studies indicate that *Sarcobatus vermiculatus* is relatively unharmed by fire, the degree of damage may vary according to season of burn, fuel loading, and intensity of fire. Fire will top kill *S. vermiculatus*, but the shrub will promptly resprout from the root crown (Daubenmire 1970).

Sarcobatus vermiculatus is not ordinarily browsed, but Daubenmire (1970) found that under heavy stocking rates, the shrubs will develop a compact canopy.



R. Rondeau

Variation: This system occurs as a mosaic of communities with open to moderately dense shrublands dominated or codominated by *Sarcobatus vermiculatus*. Greasewood dominated vegetation can occur as a narrow band along a channel, or in a mosaic of communities where composition and density of the shrub and understory species vary with depth to water table, salinity and alkalinity, soil texture, and past land use or disturbance. Occurrences may be surrounded by grasslands, stabilized sand dunes, wet meadow systems, mixed salt desert scrub, sandsage, or shortgrass prairie. Hanson (1929) described stands in south-central Colorado and found that pure stands of *S. vermiculatus* and *Distichlis spicata* are more common on strongly saline/alkaline sites with fine-textured soil and shallow water tables, whereas stands with mixed shrubs such as *Chrysothamnus* or *Artemisia* are more common on drier, coarser textured, low-alkaline sites. *Sporobolus airoides* is found on dry, strongly alkaline sites, and *Pascopyrum smithii* is most common on less alkaline, moist, sites in low lying areas.

Branson, F. A., R. F. Miller, and I. S. McQueen. 1976. Moisture relationships in twelve northern desert shrub communities near Grand Junction, Colorado. Ecology 57:1104-1124.

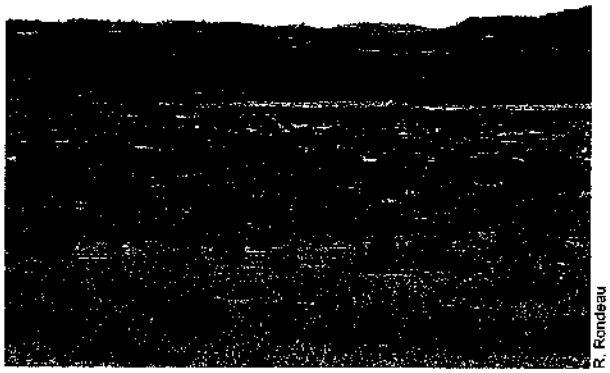
Daubenmire, R. F. 1970. Steppe vegetation of Washington. Washington State University Agricultural Experiment Station Technical Bulletin No. 62. 131 pp.

Hanson, H. C. 1929. Range resources of the San Luis Valley. Pages 5-61 in: Range resources of the San Luis Valley. Bulletin 335. Colorado Experiment Station, Fort Collins, CO.

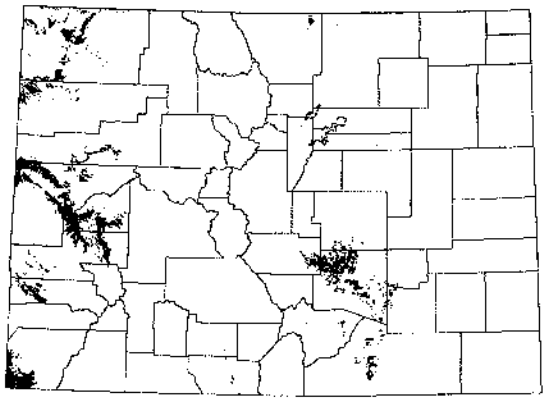
Ungar, I. A., W. Hogan, and M. McClennand. 1969. Plant communities of saline soils at Lincoln, Nebraska. The American Midland Naturalist 82(2):564-577.

Rank:	A	B	C	D
① CONDITION				
Natural hydrologic regime (Note that the hydrologic regime for this system can potentially be affected by off-site factors many miles away)	Natural hydrologic regime intact. No or little evidence of alteration due to drainage, flood control, irrigation canals, livestock grazing, digging, burming, vehicle use, etc.	Natural hydrologic regime intact or slightly altered (within 60-140% of historic means for timing and magnitude). Alteration is easily restorable by ceasing such activities.	Natural hydrologic regime altered by local drainage, diking, filling, digging, or dredging. Alteration is extensive but potentially restorable over several decades.	Natural hydrologic regime or disturbance to site not restorable. System remains fundamentally compromised despite restoration of some processes.
Invasive exotics with major potential to alter structure and composition (e.g., whitetop, leafy spurge, Russian knapweed, diffuse knapweed, spotted knapweed, yellow toadflax)	Absent to minimal (<1% cover), with no potential for expansion.	Few (1-3% cover), with little potential for expansion if restoration occurs.	May be widespread (3-7% of the occurrence with some patches larger than 1 acre) but potentially manageable with restoration of most natural processes.	May be dominant over significant portions of the area, with little potential for control.
Native increaser spp.	Not abnormally predominant.	May form dense stands over <10% of the occurrence, but do not appear to be expanding.	>10% cover, may be dominant in some areas.	
Disturbance	Livestock grazing, if present, appears to mimic native herbivory levels and patterns.	Livestock grazing appears to be compatible and in general mimics native herbivory levels and patterns.	Vehicle use or grazing disturbance is extensive and significant enough to have notable impact on species composition.	
② SIZE				
Acres A rank: Wide range of plant associations showing a range of variation in hydrology, salinity, and soil texture. Large enough to buffer most of occurrence from edge effects and small hydrologic alterations.	>1,000	100-1,000	50-100	< 50
③ LANDSCAPE CONTEXT				
Surrounding land	Wet meadows and grasslands within 1 mile of the occurrence are unaltered by urban or agricultural uses (> 90% natural).	Grasslands, shrublands and wet meadows within ¼ mile of the occurrence may have moderate urban or agricultural alteration (60-90% natural).	Adjacent grasslands, shrublands, and wet meadows are fragmented by alteration (20-60% natural). Landscape restorable over years or decades.	Adjacent lands mostly converted to agricultural or urban uses. Landscapes missing fundamental system components that render restoration unfeasible.
Landscape hydrology	No evidence of human-caused alteration of hydrology.	Limited or minor human-caused alteration of hydrology, especially groundwater pumping and canals.	Local or moderate human-caused alteration of hydrology.	Major human-caused alteration of hydrology.
Timing and depth of high and low groundwater	Little affected by groundwater pumping. Remains from 90-110% of historic patterns.	Little affected by groundwater pumping, remains from 75-90% of historic patterns.		Groundwater pumping is affecting greater than 20% of the area.
Invasive species (e.g. *Cardaria*)	None present on adjacent lands.	No or very few invasive species present on adjacent lands, and if present, easily controlled.	May be abundant on adjacent wet meadows, altering species composition.	
Connectivity Extent to which patches of natural and semi-natural vegetation allow movement of water and species across the landscape.	Connectivity allows natural ecological processes (e.g., flooding and species migration) to occur. No barriers present.	Substantial connectivity among patches of natural and semi-natural vegetation remains. Few barriers present.	Limited connectivity. Some barriers present restricting movement across system boundaries.	Connectivity is severely hampered.

INTER-MOUNTAIN BASINS MIXED SALT DESERT SCRUB



R. Rondeau



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ATRIPLEX CANESCENS SHRUBLAND ALLIANCE
- *Atriplex canescens - Artemisia tridentata* Shrubland
- *Atriplex canescens / Bouteloua gracilis* Shrubland
- *Atriplex canescens / Pleuraphis jamesii* Shrubland
- *Atriplex canescens / Sporobolus airoides* Shrubland
- *Atriplex canescens* Shrubland

ATRIPLEX CONFERTIFOLIA SHRUBLAND ALLIANCE
- *Atriplex confertifolia - Sarcobatus vermiculatus* Shrubland
- *Atriplex confertifolia / Achnatherum hymenoides* Shrubland
- *Atriplex confertifolia / Leymus salinus* Shrubland
- *Atriplex confertifolia / Pleuraphis jamesii* Shrubland
- *Atriplex confertifolia / Pseudoroegneria spicata* Shrubland
- *Atriplex confertifolia* Wyoming Basins Shrubland

KRASCHENINNIKOVIA LANATA DWARF-SHRUBLAND ALLIANCE
- *Krascheninnikovia lanata / Achnatherum hymenoides* Dwarf-shrubland
- *Krascheninnikovia lanata / Hesperostipa comata* Dwarf-shrubland

Overview: This extensive ecological system includes open-canopied shrublands of typically saline desert basins, alluvial slopes and plains across the intermountain western U.S. Considered a matrix forming system to the west of Colorado, this type also extends in limited distribution into the southern Great Plains, where it is a large patch system. Substrates are often saline and calcareous, medium- to fine-textured, alkaline soils, but include some coarser-textured soils. The vegetation is characterized by a typically open to moderately dense shrubland composed of one or more *Atriplex* species.

Characteristic species: The sparse to moderately dense cover of woody species is dominated by *Atriplex canescens* (may codominate with *Artemisia tridentata*), *Atriplex confertifolia* (may codominate with *Lycium andersonii*), *Atriplex obovata, Picrothamnus desertorum,* or *Krascheninnikovia lanata.* Other shrubs include *Purshia stansburiana, Psorothamnus polydenius, Ephedra* spp., *Acacia greggii, Encelia frutescens, Tiquilia latior, Parthenium confertum, Atriplex polycarpa, Atriplex lentiformis, Picrothamnus desertorum (= Artemisia spinescens), Frankenia salina, Artemisia frigida, Chrysothamnus* spp., *Lycium* ssp., *Suaeda* spp., *Yucca glauca,* and *Tetradymia spinosa.* Dwarf-shrubs include *Gutierrezia sarothrae* and *Eriogonum* spp. Warm-season medium-tall and short perennial grasses dominate in the sparse to moderately dense graminoid layer. Species may include *Pleuraphis jamesii, Bouteloua gracilis, Sporobolus airoides, Sporobolus cryptandrus, Achnatherum hymenoides, Elymus elymoides, Distichlis spicata, Leymus salinus, Pascopyrum smithii, Hesperostipa comata, Pseudoroegneria spicata, Poa secunda, Leymus ambiguus,* and *Muhlenbergia torreyi.* A number of annual species may also grow in association with the shrubs and grasses of this system, although they are usually rare and confined to areas of recent disturbance (Blaisdell and Holmgren 1984). Forb cover is generally sparse. Perennial forbs that might occur include

Sphaeralcea coccinea, Chaetopappa ericoides, Xylorhiza venusta, and *Mentzelia* species. Annual natives include *Plantago* spp., *Vulpia octoflora,* or *Monolepis nuttalliana.* Associated halophytic annuals include *Salicornia rubra, Salicornia bigelovii,* and *Suaeda* species. Exotic annuals that may occur include *Salsola kali* and *Bromus tectorum.* Cacti such as *Opuntia* spp. and *Echinocereus* spp. may be present in some occurrences. Trees are not usually present but some scattered *Juniperus* spp. may be found.

Environment: This system is comprised of arid to semi-arid shrublands on lowland and upland sites usually at elevations between 4,980 and 7,220 ft (1,520-2,200 m). Sites can be found on all aspects and include valley bottoms, alluvial and alkaline flats, mesas and plateaus, playas, drainage terraces, washes and interdune basins, bluffs, and gentle to moderately steep sandy or rocky slopes. Slopes are typically gentle to moderately steep, but are sometimes unstable and prone to surface movement. Many areas within this system are degraded due to erosion and may resemble "badlands." Soil surface is often very barren in occurrences of this system. The interspaces between the characteristic plant clusters are commonly covered by a microphytic crust (West 1982).

This is typically a system of extreme climatic conditions, with warm to hot summers and freezing winters. Annual precipitation ranges from approximately 5-13 in (13-33 cm). In much of the ecological system, the period of greatest moisture will be mid- to late summer, although in the more northern areas a moist period is to be expected in the cold part of the year. However, seasonality of occurrence is probably of less importance on this desert system than in other ecosystems because desert precipitation comes with an extreme irregularity that does not appear in graphs of long-term seasonal or monthly averages (Blaisdell and Holmgren 1984). Soils are shallow to moderately deep, poorly developed, and a product of an arid climate and little precipitation. Soils are often alkaline or saline.

Dynamics: West (1982) stated that "salt desert shrub vegetation occurs mostly in two kinds of situations that promote soil salinity, alkalinity, or both. These are either at the bottom of drainages in enclosed basins or where marine shales outcrop." However, salt-desert shrub vegetation may be an indication of climatically dry as well as physiologically dry soils (Blaisdell and Holmgren 1984). Species of the salt-desert shrub complex have different degrees of tolerance to salinity and aridity, and they tend to sort themselves out along a moisture/salinity gradient (West 1982). Species and communities are apparently sorted out along physical, chemical, moisture, and topographic gradients through complex relations that are not understood and are in need of further study (Blaisdell and Holmgren 1984).

The winter months within this system are a good time for soil moisture accumulation and storage. There is generally at least one good snow storm per season that will provide sufficient moisture to the vegetation. The winter moisture accumulation amounts will affect spring plant growth. Plants may grow as little as a few inches to 3 ft. Unless more rains come in the spring, the soil moisture will be depleted in a few weeks, growth will slow and ultimately cease, and the perennial plants will assume their various forms of dormancy (Blaisdell and Holmgren 1984). If effective rain comes later in the warm season, some of the species will renew their growth from the stage at which it had stopped. Others, having died back, will start over as if emerging from winter dormancy (Blaisdell and Holmgren 1984). Other communities are maintained by intra- or inter-annual cycles of flooding followed by extended drought, which favor accumulation of transported salts. The moisture supporting these intermittently flooded wetlands is usually derived off-site, and they are dependent upon natural watershed function for persistence (Reid et al. 1999).

In summary, desert communities of perennial plants are dynamic and changing. The composition within this system may change dramatically and may be both cyclic and unidirectional. Superimposed on the compositional change is great variation from year to year in growth of all the vegetation – the sum of varying growth responses of individual species to specific conditions of different years (Blaisdell and Holmgren 1984). Desert plants grow when temperature is satisfactory, but only if soil moisture is available at the same time. Because amount of moisture is variable from year to year and because different species flourish under different seasons of soil moisture, seldom

do all components of the vegetation thrive in the same year (Blaisdell and Holmgren 1984).

Variation: Occurrences of this ecological system vary from almost pure occurrences of single species to fairly complex mixtures. The characteristic mix of low shrubs and grasses is sparse, with large open spaces between the plants (Blaisdell and Holmgren 1984). The species present depend on the geographic range of the grasses, alkalinity/salinity and past land use.

Blaisdell, J. P. and R. C. Holmgren. 1984. Managing Intermountain rangelands-salt-desert shrub ranges. USDA Forest ServiceGeneral Technical Report INT-163. Intermountain Forest and Range Experiment Station, Ogden, Utah. 52 pp

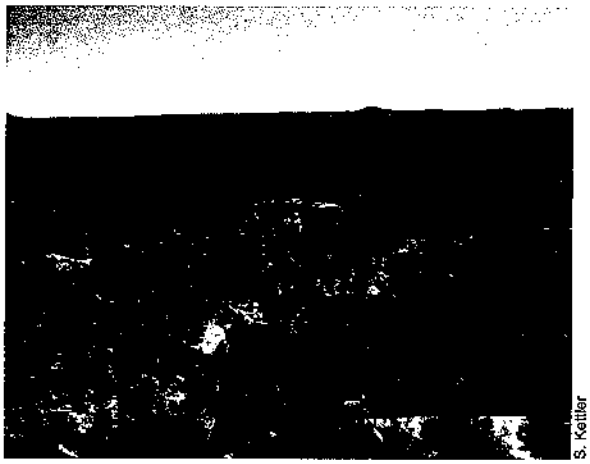
Reid, M. S., K. A. Schulz, P. J. Comer, M. H. Schindel, D. R. Culver, D. A. Sarr, and M. C. Damm. 1999. An alliance level classification of vegetation of the coterminous western United States. Unpublished final report to the University of Idaho Cooperative Fish and Wildlife Research Unit and National Gap Analysis Program, in fulfillment of Cooperative Agreement 1434-HQ-97-AG-01779. The Nature Conservancy, Western Conservation Science Department, Boulder, CO.

West, N.E. 1982. Approaches to synecological characterization of wildlands in the Intermountain West. Pages 633-643 in In-place Resource Inventories: Principles & Practices. A national workshop, Univ. of Maine, Orono. Soc. of Amer. Foresters, McClean, Va. August 9-14, 1981.

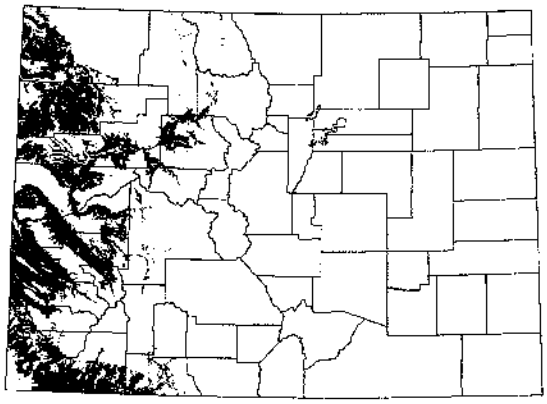
Rank:	A	B	C	D
① SIZE				
Acres (on eastern plains)	>30,000 >1,000 Sufficient internal variability to capture characteristic biophysical gradients and retain natural geomorphic disturbance. Buffered from edge effects.	10,000-30,000 100-1,000	5,000-10,000 30-100	< 5,000 <30 Too small to remain viable with altered natural geomorphic processes and contain insufficient area to maintain a diversity of plant associations. Susceptible to invasive exotics.
② CONDITION				
Community structure	A variety of structural stages are present that could provide habitat for shrubland and grassland birds.	Heterogenity of structure is present throughout the majority of the occurrence or easily re-established through management practices.	Much of the occurrence is dominated by a single structural stage, and may be lacking in vegetative species diversity.	Vegetation within the occurrence has little or no structural diversity and is likely to have low native species diversity. May be invaded by native woody species.
Native perennial increaser spp.	< 5% cover.	Community dominated by natives, native perennial increasers may be present and even dominant in spots, but not throughout the occurrence.		Dominant.
Invasive exotics with major potential to alter structure and composition (e.g., leafy spurge, Russian knapweed, diffuse knapweed, spotted knapweed, yellow toadflax)	Absent or < 1% cover.	1 to 3% of the occurrence, with no patches larger than 1 acre.	3-7% of the occurrence with some patches larger than 1 acre. May be having an impact on the stability of the system, but could be controlled with a sustained effort.	Present and widespread.
Other non-native annual spp. (e.g. *Halogeton glomeratus, Bromus tectorum, Salsola kali, S. paulsenii, Bassia hyssopifolia*)	Absent or incidental.	May be present in disturbed areas only, and are not found throughout the occurrence.	Can be present and quite abundant in small patches.	Present and abundant.
Disturbance	No surficial disturbance is evident or if present than in only small, isolated areas (e.g. ranch activities and buildings;	Surficial disturbances are limited to less than 20% of the occurrence area (e.g. mines or ranch activities and buildings;	Surficial disturbances occur on more than 20% of the area (e.g. mines or ranch activities and buildings; off-road vehicle	Surficial disturbances occur on more than 50% of the area (e.g. mines or ranch activities and buildings; off-road vehicle

	off-road vehicle use). There are few or no roads within the occurrence.	off-road vehicle use). There are only a few roads found within the occurrence.	use). There are more than a few roads found within the occurrence.	use). Many roads are found within the occurrence.
Ground cover	Microbiotic crusts are intact. Natural microrelief is undisturbed. Soil erosion is not accelerated by anthropogenic activities.	Microbiotic crusts are intact in at least 80% of the occurrence. Soil erosion may be accelerated in small patches, or lightly so throughout the occurrence.	Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence.	Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use.
③ LANDSCAPE CONTEXT				
Connectivity	Occurrence is highly connected to the surrounding landscape, which has been little altered by agriculture or development (>90% natural).	Occurrence is moderately connected to the surrounding landscape, which has been somewhat altered by agriculture or development (70-90% natural).	The occurrence is moderately fragmented and isolated, and the surrounding landscape is a mosaic of agricultural or semi-developed areas with natural or semi-natural vegetation.	The occurrence is highly fragmented and isolated.
Surrounding land	The occurrence captures the characteristic ecological gradients (including nested patch communities, e.g. washes, saltbush scrub flats) and geomorphic processes, and is largely surrounded by other high quality communities.	The occurrence captures the characteristic ecological gradients (including nested patch communities, e.g. washes, saltbush scrub flats) and geomorphic processes, and the occurrence is surrounded by other natural and semi-natural communities of at least moderate quality, such as areas that may have been used extensively for heavy livestock grazing or military training currently or in the past.	The surrounding landscape is a mosaic of agricultural or semi-developed areas with natural or semi-natural vegetation. Adjacent systems surrounding occurrence are fragmented by alteration (20-70% natural), with limited connectivity to other characteristic natural communities.	The area around the occurrence is entirely, or almost entirely, converted to agricultural or urban land use; occurrence is at best buffered on one side by natural communities. The surrounding landscape is primarily intensive agriculture or urban development.

COLORADO PLATEAU PINYON-JUNIPER WOODLAND



S. Kettler



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JUNIPERUS OSTEOSPERMA WOODED HERBACEOUS ALLIANCE
- *Juniperus osteosperma / Hesperostipa comata* Wooded Herbaceous Vegetation
- *Juniperus osteosperma / Leymus salinus* Wooded Herbaceous Vegetation

JUNIPERUS OSTEOSPERMA WOODED SHRUBLAND ALLIANCE
- *Juniperus osteosperma* Wooded Shrubland [Placeholder]

JUNIPERUS OSTEOSPERMA WOODLAND ALLIANCE
- *Juniperus osteosperma / Artemisia nova* / Rock Woodland
- *Juniperus osteosperma / Artemisia nova* Woodland
- *Juniperus osteosperma / Artemisia tridentata* ssp. *wyomingensis* Woodland
- *Juniperus osteosperma / Cercocarpus intricatus* Woodland
- *Juniperus osteosperma / Cercocarpus montanus* Woodland
- *Juniperus osteosperma / Pseudoroegneria spicata* Woodland
- *Juniperus osteosperma / Symphoricarpos oreophilus* Woodland
- *Juniperus osteosperma* Woodland

PINUS EDULIS - (JUNIPERUS SPP.) WOODLAND ALLIANCE
- *Pinus edulis - (Juniperus monosperma, Juniperus osteosperma) / Hesperostipa comata* Woodland
- *Pinus edulis - (Juniperus osteosperma) / Bouteloua gracilis* Woodland
- *Pinus edulis - Juniperus osteosperma / Cercocarpus intricatus* Woodland
- *Pinus edulis - Juniperus osteosperma / Coleogyne ramosissima* Woodland
- *Pinus edulis - Juniperus osteosperma / Purshia stansburiana* Woodland
- *Pinus edulis - Juniperus spp. / Artemisia tridentata* (ssp. *wyomingensis*, ssp. *vaseyana)* Woodland
- *Pinus edulis - Juniperus spp. / Cercocarpus montanus* Woodland
- *Pinus edulis - Juniperus* spp. / *Quercus gambelii* Woodland
- *Pinus edulis / Achnatherum scribneri* Woodland
- *Pinus edulis / Poa fendleriana* Woodland
- *Pinus edulis / Pseudoroegneria spicata* Woodland
- *Pinus edulis / Purshia tridentata* Woodland
- *Pinus edulis / Quercus* X *pauciloba* Woodland

Overview: This matrix-forming ecological system occurs on dry mountains and foothills of the Colorado Plateau region from the Western Slope of Colorado to the Wasatch Range, and south to the Mogollon Rim. It is typically found at lower elevations ranging from 4,900-8,000 ft (1,500-2,440 m). These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. *Pinus edulis* and/or *Juniperus osteosperma* dominate the tree canopy. *Juniperus scopulorum* may codominate or replace *Juniperus monosperma* at higher elevations. These woodlands often occur in a mosaic with other systems, including pinyon-juniper shrublands, sagebrush shrublands, Gambel oak shrublands and semi-desert shrublands.

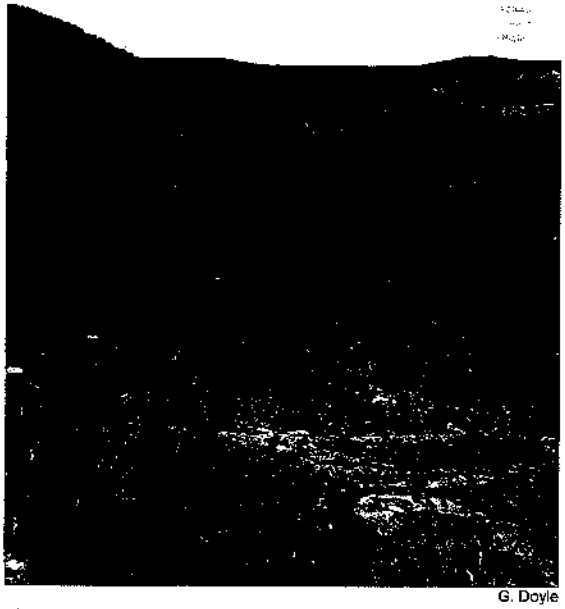
Characteristic species: These woodland associations are characterized by stands with 25-60% canopy cover of trees typically 10-30 ft (3-10 m) in height. These stands may be solely dominated by the evergreen needle-leaved tree *Pinus edulis*, or may be co-dominated by the scale-leaf evergreen tree *Juniperus osteosperma* or other *Juniperus* species. The understory ranges from a relatively rich mixture of evergreen and/or deciduous shrubs, to a sparse to moderately dense herbaceous layer dominated by perennial grasses (with or without shrubs), to no vegetation at all (Reid et al. 1999).

A sparse to moderately dense shrub layer (0-30%) may be present with little to high species diversity. Characteristic shrubs and dwarf-shrubs include *Artemisia tridentata, Arctostaphylos pungens, Amelanchier utahensis, Cercocarpus montanus, Cercocarpus ledifolius, Coleogyne ramosissima, Ephedra viridis, Gutierrezia sarothrae, Purshia mexicana, Purshia tridentata, Quercus gambelii, Quercus turbinella, Symphoricarpos oreophilus* and *Shepherdia rotundifolia.* Scattered cacti are often present, including *Opuntia* spp., *Echinocereus* spp., and *Yucca* spp.

Perennial graminoids are the most abundant species in the sparse to moderately dense (1-30% cover) herbaceous layer. Characteristic graminoid species include *Bouteloua curtipendula, Bouteloua gracilis, Aristida* spp., *Festuca arizonica, Koeleria macrantha, Hesperostipa comata, Achnatherum hymenoides, Pseudoroegneria spicata, Poa fendleriana, Pleuraphis jamesii,* and *Pascopyrum smithii. Carex* spp. may be found in more mesic sites with *Quercus gambelii.* Annual grasses may be seasonally present. The forb layer may be diverse, but has little cover. Commonly present forbs include *Artemisia, Eriogonum, Cryptantha, Aster, Solidago, Heterotheca, Mirabilis, Penstemon, Phlox, Senecio,* and *Zinnia* species. Annual forbs may be seasonally present.

Environment: Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides. Annual precipitation is usually from 12-22 in (30-55 cm) in the form of rain and snow.

Stands occur on a variety of aspects and slopes. Slope may range from nearly level to steep (up to 80%). Soils supporting this system vary in texture ranging from stony, cobbly, gravelly sandy loams to clay loam or clay. Parent materials likewise vary widely from granite, basalt, limestone, and sandstone to mixed alluvium (Springfield 1976). Soil depths may range from shallow to deep.



G. Doyle

Dynamics: The effect of a fire on a stand is largely dependent on the tree height and density, fine fuel load on the ground, weather conditions, and season (Wright et al. 1979, Dwyer and Pieper 1967). Large trees generally survive unless the fire gets into the crown due to heavy fuel loads in the understory. In this system fire acts to open stands, increase diversity and productivity in understory species, and create a mosaic of stands of different sizes and ages across the landscape while maintaining the boundary between woodlands and adjacent shrubs or grasslands (Bradley et al. 1992). Altered fire regimes, overgrazing, and tree cutting can all affect stand quality and fire behavior. These factors can also disturb cryptogamic soils and lead to increased soil erosion and habitat/species loss.

Variation: Stands vary considerably in appearance and composition, both altitudinally and geographically. Juniper tends to be more abundant at the lower elevations, pinyon tends to be more abundant at the higher elevations, and the two species share dominance within a broad middle-elevation zone (Woodin and Lindsey 1954, Heil et al. 1993). Site conditions influence the stand density. Sites with fewer trees typically have relatively deep soils and support a dense herbaceous level; those with more trees have shallow, rocky soils and often occur on steeper slopes. Stands may range from even aged to un-even aged stands. Some stands may have closed canopies with little or no understory, but many stands are open with widely scattered trees with a wide variety of understory vegetation (Rondeau 2001).

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Rondeau, R. 2001. Ecological system viability specifications for Southern Rocky Mountain ecoregion. First Edition. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO. 181 pp.

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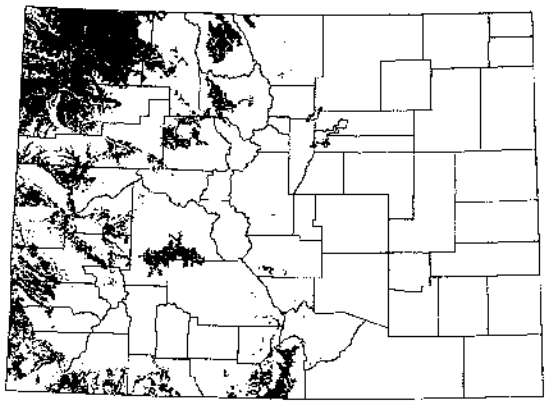
Wright, H. A., L. F. Neuenschwander, and C. M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities:A state-of-the-art review. Gen. Tech. Rep. INT-58, USDA, Forest Serv., Ogden, Utah. 49 pp.

Woodin, H. E., and A. A. Lindsey. 1954. Juniper-pinyon east of the Continental Divide, as analyzed by the pine-strip method. Ecology 35:473-489.

Rank:	A	B	C	D
① SIZE				
Acres	>30,000	10,000-30,000	5,000-10,000	< 5,000
② CONDITION				
Non-native spp. (annual grasses, e.g. *Bromus tectorum*)	Absent or incidental.	May be present in disturbed areas only.	Can be abundant in both small and large patches.	Present and abundant.
Native increaser spp.	< 5% cover.	May be present and even dominant in spots, but not throughout the occurrence.		
Disturbance (e.g. ranch activities and buildings; energy development; off-road vehicle use)	No surficial disturbance is evident, the stand has never been "chained" and re-seeded. Some disturbance may be evident in small, isolated areas (e.g. mines or ranch activities and buildings; minor off-road vehicle use--<1%). Few to no roads.	No surficial disturbance is evident, the stand has never been "chained" and re-seeded. If some disturbance is evident it is limited to less than 20% of the occurrence area (<5%). There are no to only a few roads found within the occurrence.	Surficial disturbances occur on more than 20% of the area. Up to 50% of the stand may have been "chained" and re-seeded. There are more than a few roads found within the occurrence.	Surficial disturbances occur on more than 50% of the area (e.g. mines or ranch activities and buildings; off-road vehicle use). Up to 50% of the stand may have been "chained" and re-seeded.
Ground cover	Microbiotic crusts are intact. Natural microrelief is undisturbed. Soil erosion is not accelerated by anthropogenic activities. Accelerated soil erosion had not occurred, or if in the past, the herbaceous cover has increased sufficiently to check this problem.	Microbiotic crusts intact in at least 80% of the occurrence. Soil erosion may be accelerated in small patches, or lightly so throughout the occurrence. Soil erosion can be easily reversed by relatively simple, straightforward, and inexpensive changes in management.	Microbiotic crusts are removed from more than 25% of the area, or are in various stages of degradation throughout the occurrence. Soil erosion and gullying may be observed in patches (up to 30%) within the stand.	Microbiotic crusts are >75% removed, occurring only in small pockets naturally protected from livestock and off-road vehicle use. Soil erosion may be severe in places.
③ LANDSCAPE CONTEXT				
Connectivity	Highly connected.	Moderately connected.	Moderately fragmented.	Highly fragmented.
Surrounding land	Occurrence is surrounded by a large area (>2000 ac/800 ha) of natural vegetation, that captures the characteristic ecological gradients (including adjacent large patch and surrounding matrix communities and geomorphic processes.	Landscape is composed of at least 80% natural or semi-natural vegetation, with species interactions and natural processes occurring across communities. The stand may be surrounded by an expansive semi-natural landscape that has been used extensively for grazing.	Landscape is a mosaic of agricultural or semi-developed areas and natural or semi-natural vegetation, the latter composing 25-80% of the landscape.	Occurrence is surrounded primarily by urban or agricultural landscape, with <25% landscape cover of natural or semi-natural vegetation.

INTER-MOUNTAIN BASINS BIG SAGEBRUSH SHRUBLAND


R. Rondeau



extent exaggerated for display

ARTEMISIA TRIDENTATA (SSP. TRIDENTATA, SSP. XERICENSIS) SHRUB HERBACEOUS ALLIANCE
- *Artemisia tridentata* (ssp. *tridentata*, ssp. *xericensis*) / *Pseudoroegneria spicata* Shrub Herbaceous Vegetation

ARTEMISIA TRIDENTATA (SSP. TRIDENTATA, SSP. XERICENSIS) SHRUBLAND ALLIANCE
- *Artemisia tridentata* ssp. *tridentata* / *Leymus cinereus* Shrubland
- *Artemisia tridentata* ssp. *tridentata* / *Pascopyrum smithii* - *(Elymus lanceolatus)* Shrubland
- *Artemisia tridentata* ssp. *tridentata* / *Pleuraphis jamesii* Shrubland

ARTEMISIA TRIDENTATA SHRUBLAND ALLIANCE
- *Artemisia tridentata* - *(Ericameria nauseosa)* / *Bromus tectorum* Semi-natural Shrubland
- *Artemisia tridentata* / *Pleuraphis jamesii* Shrubland

ARTEMISIA TRIDENTATA SSP. WYOMINGENSIS SHRUB HERBACEOUS ALLIANCE
- *Artemisia tridentata* ssp. *wyomingensis* / *Pascopyrum smithii* Shrub Herbaceous Vegetation
- *Artemisia tridentata* ssp. *wyomingensis* / *Pseudoroegneria spicata* Shrub Herbaceous Vegetation

ARTEMISIA TRIDENTATA SSP. WYOMINGENSIS SHRUBLAND ALLIANCE
- *Artemisia tridentata* ssp. *wyomingensis* - *Atriplex confertifolia* Shrubland
- *Artemisia tridentata* ssp. *wyomingensis* - *Purshia tridentata* / *Pseudoroegneria spicata* Shrubland
- *Artemisia tridentata* ssp. *wyomingensis* / *Achnatherum hymenoides* Shrubland
- *Artemisia tridentata* ssp. *wyomingensis* / *Elymus albicans* Shrubland
- *Artemisia tridentata* ssp. *wyomingensis* / *Leymus ambiguus* Shrubland
- *Artemisia tridentata* ssp. *wyomingensis* / *Pseudoroegneria spicata* Shrubland

Overview: This matrix forming ecological system occurs throughout the much of western U.S. In Colorado, the largest occurrences are in the western half of the state, but this system can also be found in eastern Colorado. Northwestern Colorado, North Park, Middle Park, and the upper Gunnison Basin have large and continuous stands of sagebrush shrublands. This system is characterized by a dense shrubland of taller *Artemesia* species with a significant herbaceous understory. These taller shrubs distinguish it from sagebrush steppe, which is dominated by dwarf sagebrush species.

Characteristic species: These shrublands are dominated by *Artemisia tridentata* ssp. *tridentata* and/or ssp. *wyomingensis*, or *A. cana*, with occasional component shrubs such as *Chrysothamnus* spp., *Purshia tridentata*, and *Krascheninnikovia lanata*. Scattered *Sarcobatus vermiculatus* and *Atriplex* spp. may be present in some stands. *Ericameria nauseosa* or *Chrysothamnus viscidiflorus* may codominate disturbed stands. Perennial herbaceous components typically contribute less than 25% vegetative cover. Common graminoid species include *Achnatherum hymenoides, Bouteloua gracilis, Carex geyeri, Elymus lanceolatus, Festuca idahoensis, F. thurberi, Hesperostipa comata, Leymus cinereus, Pleuraphis jamesii, Pascopyrum smithii, Poa secunda*, or *Pseudoroegneria spicata*. Sage-grouse (*Centrocercus* spp.) is an indicator of a healthy sagebrush shrubland.

Environment: Big sagebrush shrublands are typically found in broad basins between mountain ranges, on plains and foothills. This system is usually found on flat to rolling hills with well-drained clay soils between 7,000 to 10,000 feet in elevation. Soils are typically deep, well-drained and non-saline.

Dynamics: Presettlement stand-replacing fire frequency was 40-60 years, with smaller fires every 20-25 years (Wright et al. 1979). Repeated burning every few years or burning in summer will deplete a stand of perennial grasses and allow invasive forbs and cheatgrass to increase. Taller *Artemisia* shrublands are more susceptible to natural fire than dwarf shrublands.

Cheatgrass (*Bromus tectorum*) increases the likelihood of fire in mixed sagerush-cheatgrass sites, but burning may produce dominance of cheatgrass and other weeds. Following a fire sagebrush must reestablish itself from seed; growth is slow and recovery is slow (Bunting et al. 1987). Fire favors shrubs like *Ericameria nauseosus* that can re-sprout after fire. Fire supression in montane grasslands could lead to conversion to *Artemisia tridentata* shrublands. Heavy grazing increases soil water losses, so heavily grazed sites are drier. Excessive grazing also reduces the biomass of deep (>15 in or 40 cm) roots and reduces the depth and cover of litter. Trampling from livestock grazing significantly decreases the number of sagebrush and grass seedlings.

Variation: This system differs from the sagebrush steppe in that the steppe is dominated by dwarf sagebrush *(Artemisia arbuscula* and *A. nova)*. The dwarf shrublands are often found on poorly drained soils with low aeration, whereas the big sagebrush shrublands are usually on well drained and aerated soils.

P. Lyon

Bunting, S.C., B.M. Kilgore, and C.L. Bushey. 1987. Guidelines for prescribed burning sagebrush-grass rangelands in the northern Great Basin. General Technical Report INT-231, 33 pp. USDA Forest Service, Intermountain Research Station. Ogden, UT.

Wright, H.A., L.F. Neuenschwander, and C.M. Britton. 1979. The role and use of fire in sagebrush-grass and pinyon-juniper plant communities: A state-of-the-art review. General Technical Report INT-58, 48 pp. USDA Forest Service, Intermountain Research Station. Ogden, UT.

Rank:	A	B	C	D
① SIZE				
Acres	>90,000	50,000-90,000	30,000-50,000	< 30,000
② CONDITION				
Invasive exotics with major potential to alter structure and composition (e.g., non-native thistle, *Bromus inermis, Poa pratensis, Bromus tectorum)*	Absent or <1% cover.	May be present, but <3% cover.	Likely to be present.	Present.
Other non-native spp.	<5% cover, native species dominant.	<10% cover, native species dominant.	Co-dominant with native species.	Dominant.
Native increaser spp. *(Balsamorriza, Wyethia, Gutierrezia sarothrae)*	< 3% cover.	<10% cover.	>10% cover.	May be dominant.
Community structure	If trees are present, these are widely scattered and mature. Species richness is often high, and native bunch grasses or sedges (non-increasers) are dominant.	If trees are present, these are widely scattered and mature. Species richness is often high, and native grasses (non-increasers) are dominant.	Alteration of vegetation is extensive but potentially restorable over several decades.	Alteration of vegetation is extensive and restoration potential is low.
Disturbance	Few to no roads.	Few roads.	Vehicle use or livestock grazing disturbance, if present, is extensive and significant.	Vehicle use or livestock grazing disturbance, if present, is extensive and significant.
Ground cover	Soil erosion is not accelerated by anthropogenic activities.	Accelerated soil erosion may be present in isolated patches.	Disturbance has had notable impact on species composition, soil compaction, and soil erosion.	Disturbance has had notable impact on species composition, soil compaction, and soil erosion.
③ LANDSCAPE CONTEXT				
Connectivity	Connectivity of adjacent systems allows natural ecological processes, e.g., fire, and species migrations to occur. No unnatural barriers present.	Adjacent systems surrounding occurrence retain much connectivity. Few non-natural barriers present.	Adjacent systems surrounding occurrence are fragmented by alteration with limited connectivity.	Connectivity is severely hampered.
Surrounding land	At least 90% native and unaltered landscape with very little to no urban development or agriculture, and little to no industrial forestry.	Surrounding landscape composed of at least 75% natural or semi-natural vegetation, with little urban development within or adjacent to the occurrence.	Surrounding landscape is a mosaic of agricultural or semi-developed areas with >50% natural or semi-natural vegetation. Some non-natural barriers are present. Significant disturbance, but easily restorable.	Major human-caused alteration of surrounding landscape. Adjacent systems surrounding occurrence are mostly converted to agricultural or urban uses.

Appendix . Big game and State Wildlife Action Plan Tier 1 and 2 species known or expected to occur on or near the Cameo Shooting Sports Complex

Group	Common Name	Scientific Name	SWAP	Occurrence	Abundance
Amphibians	Great Basin spadefoot	*Spea intermontana*	Tier 2	May occur	Uncommon
Birds	Chukar	*Alectoris chukar*	Game Sp	Known to occur	Common
Birds	Mourning dove	*Zenaida macroura*	Game Sp	Known to occur	Fairly Common
Birds	Golden eagle	*Aquila chrysaetos*	Tier 1	Known to occur	Fairly Common
Birds	American peregrine falcon	*Falco peregrinus anatum*	Tier 2	Known to occur	Fairly Common
Birds	Bald eagle	*Haliaeetus leucocephalus*	Tier 2	Likely to occur	Fairly Common
Birds	Brewer's sparrow	*Spizella breweri*	Tier 2	May occur	Common
Birds	Gray vireo	*Vireo vicinior*	Tier 2	May occur	Common
Birds	Juniper titmouse	*Baeolophus ridgwayi*	Tier 2	Likely to occur	Fairly Common
Birds	Lazuli bunting	*Passerina amoena*	Tier 2	Likely to occur	Fairly Common
Birds	Loggerhead shrike	*Lanius ludovicianus*	Tier 2	May occur	Uncommon
Birds	Northern harrier	*Circus cyaneus*	Tier 2	May occur	Uncommon
Birds	Pinyon jay	*Gymnorhinus cyanocephalus*	Tier 2	Likely to occur	Fairly Common
Birds	Prairie falcon	*Falco mexicanus*	Tier 2	May occur	Uncommon
Birds	Rufous hummingbird	*Selasphorus rufus*	Tier 2	May occur	Common
Birds	Sage sparrow	*Amphispiza belli*	Tier 2	May occur	Common
Mammals	Black bear	*Ursus americanus*	Game Sp	May occur	Common
Mammals	Bobcat	*Lynx rufus*	Game Sp	Known to occur	Common
Mammals	Coyote	*Canis latrans*	Game Sp	Known to occur	Abundant
Mammals	Mountain lion	*Felis concolor*	Game Sp	Known to occur	Common

Mammals	Mule deer	*Odocoileus hemionus*	Game Sp	Known to occur	Abundant
Mammals	Ringtail	*Bassariscus astutus*	Game Sp	Likely to occur	Unknown
Mammals	Fringed myotis	*Myotis thysanodes*	Tier 1	May occur	Uncommon
Mammals	Spotted bat	*Euderma maculatum*	Tier 1	Likely to occur	Unknown
Mammals	Townsend's big-eared bat	*Corynorhinus townsendii*	Tier 1	Likely to occur	Common
Mammals	Big free-tailed bat	*Nyctinomops macrotis*	Tier 2	May occur	Uncommon
Mammals	Bighorn sheep	*Ovis canadensis*	Tier 2	Known to occur	Common
Mammals	Hoary bat	*Lasiurus cinerius*	Tier 2	May occur	Common
Reptiles	Midget faded rattlesnake	*Crotalus viridis concolor*	Tier 2	Known to occur	Uncommon

APPENDIX M –

CAMEO Wildlife Occurrence Detail
NW Terrestrial Section

This assessment identifies big game species and other wildlife species noted in Colorado Parks and Wildlife's (CPW) State Wildlife Action Plan (CPW 2015) that have been confirmed or are likely to occur on or near the property proposed for the Cameo Sports Shooting and Outdoor Education Complex (Appendix A). Three key species, peregrine falcon, golden eagle, and bighorn sheep, were selected for further discussion. All three have been confirmed using this area from prior survey work conducted by CPW and are addressed below in more detail.

Peregrine falcon:
Peregrine falcons have used several historic eyrie sites along the south and east face of Mt. Lincoln, and in the cliffs below the topographic point labeled "6100" (near the label 5/25/2011) due north of Cameo (See Figure 1, CPW Raptor Database, 2016). Post-delisting surveys conducted in the spring and early summer of 2009 and 2012 did not confirm an active eyrie in the area. The peregrine eyrie on the southern end of Mount Lincoln was active as recently as 2006. The eyries closer to Cameo on the north end of Mount Lincoln and close to Point 6100 were active throughout the 1990's and as recently as 2003. Since that time the status of these eyries has been considered inactive as no nesting pairs of peregrines have been confirmed. Surveys conducted during 2015 did note peregrines soaring around eyrie 7112G (Figure 1, label 7/6/2015) on two separate occasions, suggesting that use of this or another closely located eyrie may have been established but simply not identified during one of the three visits required by the monitoring protocol (Figure 1). However, no nesting use of the eyrie site was observed. Additional eyries occur throughout the surrounding Grand Valley with the next closest nest site noted at Mount Garfield, which was confirmed to be active in 2015. These birds could be expected to utilize air space along and adjacent to the tall cliff faces surrounding Mount Lincoln as they hunt predominantly for small passerines (Righter et al. 2004). High occupancy rates of monitored nests in Colorado suggest that this species is recovering from historic crashes noted in the late 1960's (Rossi 2015). These potential eyries lie adjacent to area proposed for the Cameo Sports Shooting and Outdoor Education Complex. They are located on cliff faces several hundred feet above the valley floor.

Recreational disturbances have been demonstrated to have a number of impacts on raptors, including altering distributions, disrupting nesting activities, abandoning breeding territories, reducing productivity, and changing foraging behavior (Knight and Skagan 1988). Spatial and temporal buffer zones are commonly implemented to avoid such disturbances (Suter and Joness 1981, Richardson and Miller 1997, CPW 2008). CPW's (2008) raptor buffer guidelines suggest:

> "No surface occupancy (beyond that which historically occurred in the area) within ½ mile radius of active nests. Seasonal restriction to human encroachment within ½ mile of the nest cliff(s) from March 15 to July 31. Due to propensity to relocate nest sites, sometimes up to ½ mile along cliff faces, it is more appropriate to designate 'Nesting Areas' that encompass the cliff system and a ½ mile buffer around the cliff complex."

CPW defines active nest sites as those that have been occupied within the previous 5 years. None of the peregrine eyrie sites in proximity to the Cameo site would be considered active under this definition, as no nest occupancy has been documented at the sites within the past 5 years. Areas used by peregrines with the greatest potential overlap of proposed facilities would be the walking rifle course below the face where the 2015 sightings were made and facilities on the bench above the river

to the southeast of Mount Lincoln's main cliff face, where the last active eyrie was confirmed in 2006. Figure 1 shows the extent of the recommended ½ mile buffers around the historic eyrie sites and the cliff system overlap with some proposed facilities occurs. Facilities planned for locations previously developed by the Xcel power plant and other industrial development on the Cameo site probably create less of a disturbance to peregrines than development in pristine areas, as peregrines have likely developed a tolerance for activity in those areas (CPW 2008). The substantial vertical separation between the Cameo facilities and the eyrie sites would also reduce potential disturbance should the eyrie sites become active in the future.

Golden eagle:
Golden eagles have used two historic nest sites near Cameo, one on the bench below Mount Lincoln's southeast face and one north of the topographic point labeled "6100" (near the label 5/25/2011) due north of Cameo (See Figure 1, CPW Raptor Database, 2016). The two nests were originally located by USFWS surveys along the Book Cliffs. CPW first checked their status in 1999 with activity not determined. Surveys conducted in May and June of 2011 did not find golden eagles present. The status of the two golden eagle nests has been inactive or undetermined since the early 1980's. No golden eagle nest sites are currently known to be active in the immediate vicinity of the Cameo site.

CPW raptor buffer guidelines for golden eagles recommend:

> "No surface occupancy (beyond that which historically occurred in the area) within ¼ mile radius of active nests. CPW defines active nest sites as those that have been occupied within the previous 5 years. Seasonal restriction to human encroachment within ½ mile radius of active nests from December 15 through July 15."

Historic golden eagle nest site buffers used in this area overlap facilities planned for the bench south of Mount Lincoln and north of the river. The second site on the north side of Point 6100, although within the ½ mile buffer, is less likely to experience disturbance given its location, if it were to become active again. The introduction of new disturbances, particularly disturbances that vary in timing, duration, and intensity, during the nesting period could affect the ability of eagles to occupy the sites or nest successfully in the future (Suter and Joness 1981, Andersen et al. 1990, Romin and Muck 1999). Golden eagles are covered by the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c) which prohibits the take of any eagle without a permit from USFWS. Included within the definition of take is the word "disturb", which is defined as "to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior." Adherence to established spatial and temporal buffers has generally been sufficient to avoid a finding of take based on disturbance. However, these golden eagle nest sites have not been found active in the last 5 years, suggesting that previous development at the site may have led to abandonment many years ago.

Yellow-billed Cuckoo:
The western distinct population segment of the Yellow-billed Cuckoo occurs in riparian forests and associated riparian shrublands along rivers in the western United States, including Colorado. Colorado is peripheral to Yellow-billed Cuckoo range and distribution in Colorado is very limited. The western distinct population segment of the species was given threatened status under the federal Endangered Species Act in 2014. Preliminary proposed critical habitat for the western distinct population segment consists of seven river reaches in Colorado, including, in part, segments of the Yampa River in Routt and Moffat counties, the Colorado river in Mesa County, and the Uncompahgre and Gunnison rivers

south and east of Delta, CO, respectively. Revised proposed critical habitat designations have been expected from the U.S. Fish and Wildlife Service for a year or more but have not yet been released. The State of Colorado argued that the species should not be listed in Colorado and that critical habitat should not be designated in Colorado, due to the limited nature of Yellow-billed Cuckoo occurrence in the state.

CPW does not have evidence that the species occupies the Cameo site, and the species was purposely excluded from the species list provided in the initial description of wildlife issues affecting the Cameo site. Critical habitat unit 55 (map attached) includes approximately 25 miles of the Colorado River in the Grand Valley, extending from Palisade (just upstream of the Highway 6 crossing of the Colorado River) downstream through the city of Grand Junction. The Cameo site is 3+/- miles upstream of proposed critical habitat.

Yellow-billed Cuckoos are secretive and difficult to survey. Survey efforts have also been inconsistent. However, only 28 sightings have been recorded in Mesa County in the 20 years between 1995 and 2015. With the exception of 3 sightings in the Plateau Creek drainage, all of the sightings have been west of Palisade. The closest sighting to the Cameo site occurred on the Tillie Bishop State Wildlife Area immediately downstream of Palisade in 2014. This location is approximately 4.1 straight-line miles downstream of the Cameo site.

Suitable habitat for the species was described in a letter from the Fish and Wildlife Service to Mesa County (March 3, 2016; copy attached):

> "Suitable habitat typically consists of multi-storied woody riparian vegetation with both an overstory of tall trees and an understory of shrubs. Suitable habitat does not include grasses or forbs although herbaceous vegetation is often present within the understory and cuckoos have been observed foraging on the ground amongst herbaceous vegetation. Both native vegetation (cottonwoods, willow, etc.) and non-native vegetation (Siberian elm, Russian olive, tamarisk, ash, etc.) may be used for nesting and foraging, although as the dominance of tamarisk increases, the chance of a cuckoo occupying a patch decreases. The minimum size of a suitable habitat patch that can support a cuckoo territory, which may include both nesting and foraging habitat, is 5 hectares (ha) or 12 acres (ac). Within this patch there needs to be an area at least 100 meters (m) (328 feet (ft)) wide and at least 100 m (328 ft) long with multi-storied woody vegetation. Within patches of habitat, cuckoos select specific nest sites that have at least 70 percent canopy cover. Foraging areas have varying levels of canopy cover, often much less than 70 percent. Foraging areas can consist of single large trees or narrow bands of trees but are typically not more than 400 m (1312 ft) from the edge of suitable nesting habitat. Woody vegetation further than 400 m (1312 ft) from the edge of a suitable habitat patch is considered another habitat patch as cuckoos typically do not fly over larger open areas during the breeding season. Currently, and for the purposes of this letter, the breeding season extends from June 1st to August 31st."

While these habitat conditions are fairly common in cottonwood gallery forests within the proposed critical habitat segment in the Grand Valley, suitable habitat conditions are unlikely to occur within the Cameo site. Riparian vegetation at the Cameo site is characterized by small patches of riparian shrubs with few tall trees that are isolated from larger riparian woodlands.

In the letter to Mesa County referenced above, the Fish and Wildlife Service also listed activities that are not expected to result in "take" of the species or its habitat under the Endangered Species Act. This

list includes “housing or commercial development in areas at least 800 m (2,624 ft.) away from suitable yellow-billed cuckoo habitat. The Cameo development is largely located away from riparian vegetation and no riparian disturbance will occur.

In summary, the potential for impacts from the Cameo site development on Yellow-billed Cuckoo seems very slight:

- the species is not known to occupy the site,
- its occurrence in the state is limited,
- the site is located approximately 3+ miles from proposed critical habitat,
- the closest known occurrence is approximately 4+ miles from the site
- habitat at the site is limited and of poor suitability,
- riparian vegetation disturbance will not occur and most facilities are located away from riparian areas.

Southwestern Willow Flycatcher:
Southwestern Willow Flycatchers are often mentioned as occurring with Yellow-billed Cuckoos. While historically considered to occur in the Grand Valley, the subspecies separation line for Southwestern Willow Flycatchers was moved south a number of years ago. Only southwestern Colorado is now believed to be within potential range for the subspecies. The subspecies does not occur at the Cameo site.

Mexican Spotted Owl:

Mexican Spotted Owls are not known to occur on the Cameo site. The Second Colorado Breeding Bird Atlas (2016, pp 262-263) documents occurrences of the species detected during that statewide survey effort. Detected occurrences were limited to central and southwestern Colorado, but Mexican spotted owls are believed to occur in small isolated populations in deep canyons and cliff bands and are principally characterized by tall stands of mixed conifers or Douglas fir. Species distribution in western Colorado in Birds of Western Colorado Plateau and Mesa Country (Righter et al. 2004) is limited to a small area of Montezuma County in extreme southwestern Colorado, although the authors note that the species is found in Utah along the Colorado border north to Dinosaur National Monument. Observations of Mexican Spotted Owls are very limited in northwestern Colorado, but include a sighting within the Yampa River Canyon inside Dinosaur National Monument. That sighting occurred on a north-facing slope in a dense stand of Douglas fir. The canyons above the Cameo site are mostly open, south-facing slopes that have limited vegetation, consisting principally of scrubby juniper-dominated woodlands and generally lacking the mixed conifers or Douglas fir that typify Mexican Spotted Owl habitat.

Bighorn sheep:
Although a hunted big game species, bighorn sheep are also included in the State Wildlife Action Plan as a Tier 2 species of greatest conservation need. Rocky Mountain bighorn sheep were reintroduced to the area around the Cameo site beginning in 2003. The herd, known as Main Canyon (Data Analysis Unit S-75), numbers approximately 50 individuals and ranges throughout Main and Coal Canyons in the project area and north to Horseshoe Canyon. Colorado's Bighorn Sheep Management Plan (George et al. 2009) further divides bighorn sheep populations into management tiers (no to be confused with the Wildlife Action Plan tier above) of descending priority based on the size of the population and whether it is native or introduced. Primary core (Tier 1) herds are native herds with >100 sheep. Secondary core (Tier 2) herds are those of >75 sheep that are either native or result from translocations. As an introduced herd of approximately 50 sheep, Main Canyon does not qualify for inclusion in either of the priority sheep management tiers.

Since the sheep were released in Main Canyon, CPW has closely monitored movement and range using both radio telemetry and GPS collars. Species activity maps were updated in July 2014 for this area using the most recent data available at the time. Since 2014, GPS collar data have dramatically improved information about habitat use by this herd and CPW staff anticipates incorporating these valuable data into the Species Activity Map data set at the next regularly scheduled 4-year map revision interval.

The area proposed for the Cameo shooting range is currently mapped as bighorn sheep overall, summer, and winter ranges. Portions of the area are mapped as winter concentration areas and severe winter range (Figure 2). The Cameo site is also within approximately 100 meters of a mapped bighorn sheep production area (Figure 3). GPS collar data show that the areas adjacent to the proposed walking rifle courses and small bore rifle and pistol ranges are used heavily during the lambing period of April 15 – June 30, and should be included with mapped production areas. Displacement of bighorn sheep by human activity has been documented, particularly by mining, walking with dogs, and specific winter activities (George et al 2009). Sheep may habituate to consistent and predictable disturbance as long as suitable forage, water, and escape terrain are accessible.

CPW maintains a set of Best Management Practices for avoiding, minimizing and/or mitigating human disturbance to a variety of wildlife species, including bighorn sheep. These Best Management Practices were updated and revised in the fall of 2016. Although developed primarily for mitigating the effects of oil and gas development, CPW recommends these voluntary mitigative measures for a variety of land development projects in land use comments prepared for local governments and federal land management agencies. Land developers are asked to consider the following Best Management Practices for avoiding, minimizing, and/or mitigating impacts to bighorn sheep, which are paraphrased below:

> These guidelines recommend that no new oil and gas operations be developed within CPW-identified bighorn sheep wintering or production areas. If operations must occur in bighorn sheep winter range CPW recommends that all activity be precluded from November 1 through April 15. Additionally, if operations must occur in bighorn sheep production areas CPW recommends that all activity be precluded from April 15 to June 30. CPW guidelines also recommend that all low elevation helicopter overflights be

precluded within one mile of production areas and winter ranges during the above-mentioned critical time periods. CPW also recommends that surface facility density be limited to one facility per square mile in bighorn sheep winter range and production areas. If the surface facility density exceeds one per square mile, CPW recommends compensatory mitigation. These guidelines also recommend that visitation to identified winter habitat be restricted to the hours of 10:00 a.m. to 3:00 p.m. and encourage mutually agreed upon limits of daily vehicle trips during winter months.

Note that these Best Management Practice recommendations are principally used for areas of heavy industrial development, and that bighorn sheep can develop tolerance for some degree of human activity, particularly where it occurs consistently/dependably and is of limited severity.

APPENDIX N – Federally Protected Species that Could Occur at the CAMEO Project Site

IPaC Information for Planning and Consultation **U.S. Fish & Wildlife Service**

IPaC resource list

This report is an automatically generated list of species and other resources such as critical habitat (collectively referred to as *trust resources*) under the U.S. Fish and Wildlife Service's (USFWS) jurisdiction that are known or expected to be on or near the project area referenced below. The list may also include trust resources that occur outside of the project area, but that could potentially be directly or indirectly affected by activities in the project area. However, determining the likelihood and extent of effects a project may have on trust resources typically requires gathering additional site-specific (e.g., vegetation/species surveys) and project-specific (e.g., magnitude and timing of proposed activities) information.

Below is a summary of the project information you provided and contact information for the USFWS office(s) with jurisdiction in the defined project area. Please read the introduction to each section that follows (Endangered Species, Migratory Birds, USFWS Facilities, and NWI Wetlands) for additional information applicable to the trust resources addressed in that section.

Location

Mesa County, Colorado

Local office

Western Colorado Ecological Services Field Office

(970) 243-2778
(970) 245-6933

445 West Gunnison Avenue, Suite 240
Grand Junction, CO 81501-5711

http://www.fws.gov/mountain-prairie/es/Colorado/
http://www.fws.gov/platteriver/

Endangered species

This resource list is for informational purposes only and does not constitute an analysis of project level impacts.

The primary information used to generate this list is the known or expected range of each species. Additional areas of influence (AOI) for species are also considered. An AOI includes areas outside of the species range if the species could be indirectly affected by activities in that area (e.g., placing a dam upstream of a fish population, even if that fish does not occur at the dam site, may indirectly impact the species by reducing or eliminating water flow downstream). Because species can move, and site conditions can change, the species on this list are not guaranteed to be found on or near the project area. To fully determine any potential effects to species, additional site-specific and project-specific information is often required.

Section 7 of the Endangered Species Act **requires** Federal agencies to "request of the Secretary information whether any species which is listed or proposed to be listed may be present in the area of such proposed action" for any project that is conducted, permitted, funded, or licensed by any Federal agency. A letter from the local office and a species list which fulfills this requirement can **only** be obtained by requesting an official species list from either the Regulatory Review section in IPaC (see directions below) or from the local field office directly.

For project evaluations that require USFWS concurrence/review, please return to the IPaC website and request an official species list by doing the following:

1. Draw the project location and click CONTINUE.
2. Click DEFINE PROJECT.
3. Log in (if directed to do so).
4. Provide a name and description for your project.
5. Click REQUEST SPECIES LIST.

Listed species

[1] are managed by the Ecological Services Program of the U.S. Fish and Wildlife Service.

1. Species listed under the Endangered Species Act are threatened or endangered; IPaC also shows species that are candidates, or proposed, for listing. See the listing status page for more information.

The following species are potentially affected by activities in this location:

Mammals

NAME	STATUS
North American Wolverine Gulo gulo luscus No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/5123	Proposed Threatened

Birds

NAME	STATUS
Mexican Spotted Owl Strix occidentalis lucida There is **final designated** critical habitat for this species. Your location is outside the critical habitat. https://ecos.fws.gov/ecp/species/8196	Threatened
Yellow-billed Cuckoo Coccyzus americanus There is **proposed** critical habitat for this species. Your location is outside the critical habitat. https://ecos.fws.gov/ecp/species/3911	Threatened

Fishes

NAME	STATUS
Bonytail Chub Gila elegans There is **final designated** critical habitat for this species. Your location is outside the critical habitat. https://ecos.fws.gov/ecp/species/1377	Endangered
Colorado Pikeminnow (=squawfish) Ptychocheilus lucius There is **final designated** critical habitat for this species. Your location overlaps the critical habitat. https://ecos.fws.gov/ecp/species/3531	Endangered
Greenback Cutthroat Trout Oncorhynchus clarki stomias No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/2775	Threatened
Humpback Chub Gila cypha There is **final designated** critical habitat for this species. Your location is outside the critical habitat. https://ecos.fws.gov/ecp/species/3930	Endangered
Razorback Sucker Xyrauchen texanus There is **final designated** critical habitat for this species. Your location overlaps the critical habitat. https://ecos.fws.gov/ecp/species/530	Endangered

Flowering Plants

NAME	STATUS
Colorado Hookless Cactus Sclerocactus glaucus No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/2280	Threatened
Debeque Phacelia Phacelia submutica There is **final designated** critical habitat for this species. Your location is outside the critical habitat. https://ecos.fws.gov/ecp/species/4639	Threatened

Critical habitats

Potential effects to critical habitat(s) in this location must be analyzed along with the endangered species themselves.

This location overlaps the critical habitat for the following species:

NAME	TYPE
Colorado Pikeminnow (=squawfish) Ptychocheilus lucius https://ecos.fws.gov/ecp/species/3531#crithab	Final designated
Razorback Sucker Xyrauchen texanus https://ecos.fws.gov/ecp/species/530#crithab	Final designated

Migratory birds

Certain birds are protected under the Migratory Bird Treaty Act

[1] and the Bald and Golden Eagle Protection Act[2].

Any activity that results in the take (to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct) of migratory birds or eagles is prohibited unless authorized by the U.S. Fish and Wildlife Service

[3]. There are no provisions for allowing the take of migratory birds that are unintentionally killed or injured. Any person or organization who plans or conducts activities that may result in the take of migratory birds is responsible for complying with the appropriate regulations and implementing appropriate conservation measures, as described below.

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

COLORADO PARKS AND WILDLIFE
CAMEO SHOOTING RANGE PHASES 1A AND 1B
THREATENED AND ENDANGERED PLANT SPECIES SURVEY REPORT

MESA COUNTY, COLORADO

Cover Photo: View of suitable Colorado hookless cactus habitat present in the project area.

Prepared For:
Colorado Parks and Wildlife (CPW)
1616 Sherman St.
Denver, CO 80203

Prepared By:
WestWater Engineering
2516 Foresight Circle #1
Grand Junction, CO 81505
Phone: 970-241-7076

October 2017

INTRODUCTION

At the request of Colorado Parks and Wildlife (CPW), WestWater Engineering (WestWater) biologists conducted threatened and endangered plant surveys for the proposed Cameo Shooting Range Phases 1A and 1B. The proposed project would be located on privately owned lands in Sections 27 and 28, Township 10 South, Range 98 West (Figure 1). The proposed project includes a rifle/pistol range (Phase 1A) and a sporting clays course (Phase 1B).

The purpose of the threatened and endangered plant survey was to identify suitable habitat and record locations of Colorado hookless cactus (*Scelerocactus glaucus*) and DeBeque phacelia (*Phacelia submutica*). Both plants are listed as threatened under the Endangered Species Act. Surveys were conducted by WestWater biologists from September 20 to September 22, 2017.

PROJECT AREA DESCRIPTION

Terrain

The proposed project would be situated at the mouth of Coal Canyon near the Colorado River at an elevation of approximately 4,500 feet. The area surrounding the project is composed of canyon walls rising steeply to cliffs and narrow ridgelines. Intermittent drainages, including Coal Canyon, generally drain towards the east into the Colorado River. The project would be situated near the recently abandoned and reclaimed Cameo Power Plant and Cameo coal mine.

Soils and Geology

Soils present in the project area are typically colluvium and alluvium, derived from limestone, siltstone, and sandstone, and occur along mesas, hills, mountains, terraces, and floodplains (NRCS 2017). Soils types occurring in the project area are described in Table 1 (NRCS 2017).

Table 1. Soil types occurring within the project area.

Map Unit Symbol	Map Unit Name	Soil Type Description
15	Cameo fine sandy loam, 1 to 6 percent slopes	This soil type was developed from calcareous, stratified, mixed material alluvium. Occurs along floodplains and terraces.
66	Torriorthents, warm-rock outcrop complex, 35 to 90 percent slopes	This soil type was developed from colluviums derived from limestone and siltstone and/or colluvium derived from sandstone and shale and/or residuum weathered from sandstone and shale. Occurs along ridges, canyons, hills, and mountains.
70	Uffens loam, 1 to 8	Developed from mixed material alluvium.

Table 1. Soil types occurring within the project area.

Map Unit Symbol	Map Unit Name	Soil Type Description
	percent slopes	Occurs along mesas and terraces.

The proposed Phase 1A shooting range would be situated within alluvial deposits and the Mesaverde Group or Formation (Ellis and Gabaldo 1989). The proposed Phase 1B sporting clays course would be situated entirely on the Mesaverde Group Formation. There are no outcrops of the Wasatch Formation within the proposed project boundaries or within 300 meters of project features.

Vegetation

Vegetation communities present in the survey area include sagebrush shrublands (*Artemesia tridentata* ssp. *tridentata*) intermixed with greasewood (*Sarcobatus vermiculatus*); desert shrublands primarily composed of shadscale saltbush (*Atriplex confertifolia*), four-winged saltbush (*Atriplex canescens*), and broom snakeweed (*Gutierrezia sarothrae*); and recently reclaimed areas that have been seeded with perennial grasses and forbs. A list of common plant species observed is provided in Table 2.

Table 2. Common plant species occurring in the project area.

Common Name	*Scientific Name*	Abundance*	Habitat Type
Grasses			
Annual wheatgrass	*Eremopyrum triticeum*	xx	Reclaimed Areas
Cheatgrass	*Bromus tectorum*	xxx	Reclaimed Areas/ Desert Shrublands
Crested wheatgrass	*Agropyron cristatum*	xx	Reclaimed Areas
Galletagrass	*Pleuraphis jamesii*	x	Desert Shrublands
Saline wildrye	*Leymus salinus*	xx	Desert Shrublands
Sand dropseed	*Sporobolus cryptandrus*	xx	Desert Shrublands/ Reclaimed Areas
Forbs			
Burningbush	*Kochia scoparia*	x	Disturbed/Reclaimed Areas
Kingcup cactus	*Echinocereus triglochidiatus*	xx	Desert Shrublands
Clasping pepperweed	*Lepidium perfoliatum*	xx	Disturbed/Reclaimed Areas
Curlycup gumweed	*Grindelia squarrosa*	xx	Desert Shrublands/ Reclaimed Areas
Long-leaf phlox	*Phlox longifolia*	xx	Desert shrublands
Mountain pepperweed	*Lepidium montanum*	xx	Desert Shrublands
Palmer's penstemon	*Penstemon palmeri*	xx	Reclaimed Areas
Prickly lettuce	*Lactuca serriola*	x	Disturbed
Spiny phlox	*Phlox hoodii*	xx	Desert Shrublands

Table 2. Common plant species occurring in the project area.

Common Name	*Scientific Name*	Abundance*	Habitat Type
Rose heath	*Chaetopappa ericoides*	xx	Desert Shrublands
Scarlet globemallow	*Sphaeralcea coccinea*	xx	Desert Shrublands/ Reclaimed Areas
Utah sweetvetch	*Hedysarum boreale*	xx	Desert Shrublands
Yucca	*Yucca harrimaniae*	xx	Desert Shrublands
Shrubs/Trees			
Big sagebrush	*Artemisia tridentata*	x	Desert Shrublands/ Reclaimed Areas
Black sage	*Artemisia nova*	x	Desert Shrublands
Broom snakeweed	*Gutierrezia sarothrae*	xxx	Desert Shrublands/Reclaimed Areas
Crispleaf buckwheat	*Eriogonum corymbosum*	xx	Desert Shrublands
Four-winged saltbush	*Atriplex canescens*	xxx	Desert Shrublands/ Reclaimed Areas
Greasewood	*Sarcobatus vermiculatus*	xx	Greasewood Flats/Reclaimed Areas
Rubber rabbitbrush	*Ericameria nauseosa*	xxx	Desert Shrublands/ Reclaimed Areas
Shadscale saltbush	*Atriplex confertifolia*	xx	Desert Shrublands
Utah juniper	*Sabina utahensis*	x	Desert Shrublands

*Abundance:
x= uncommon, infrequently observed throughout survey area
xx= moderate frequency throughout survey area
xxx = common, frequently encountered throughout survey area

SURVEY METHODS

Field data, including general project location, boundaries, and reported features, were verified and/or recorded with the aid of handheld global positioning system (GPS) receivers utilizing NAD83 map datum, with coordinate locations based on the Universal Transverse Mercator (UTM) coordinate system in Zone 12. Photographs were taken of the general project location, vegetation, wildlife, and terrain.

Prior to conducting field surveys, reference books, the WestWater field database (WestWater 2017), USGS geologic maps, and aerial imagery were reviewed to determine potential habitats and species that may be present within the project area. WestWater biologists also discussed the project with the U.S.Fish and Wildlife Service (USFWS) biologist regarding species-specific surveys that would be required for this project.

Vegetation types were determined through field identification of plants, aerial photography, and on-the-ground assessment of plant abundance visible during the survey. Identification of plant

species was aided by using pertinent published field guides (Whitson et al. 2006, CWMA 2013, Kershaw et al. 1998, Weber and Wittmann 2012, Ackerfield 2015) and descriptions of habitat provided by the CNHP (Spackman et al. 1997 and CNHP 2017).

Threatened and endangered plant surveys were conducted during September of 2017 within 100 meters of the proposed project disturbance boundaries for Colorado hookless cactus (*Scelerocactus glaucus*) and within 300 meters of project disturbance boundaries for DeBeque phacelia (*Phacelia submutica*).

Threatened and endangered plant surveys were conducted in accordance with the USFWS Draft Guidance for Section 7 Consultations that include Plants in the State of Colorado (USFWS 2007). Surveys for cactus were conducted outside the flowering period for this species, and transect spacing was 1-2 meters apart in suitable habitat. Transect spacing varied depending upon navigability of the terrain, visibility, and habitat suitability. The determination of the appropriate flowering period and the presence/absence of suitable habitat for threatened and endangered plants were based on the Colorado Natural Heritage Program (CNHP) Rare Plant Field Guide (Spackman et al. 1997) and website (CNHP 2017), and WestWater biologists' observations in the area. Because the survey was conducted outside the flowering and growing season for DeBeque phacelia, only surveys for suitable habitat were completed. Any areas identified as suitable habitat would need to be verified for the presence or absence of plants during an appropriate year when known populations of DeBeque phacelia are confirmed to be growing at other nearby sites.

RESULTS

Threatened and endangered plant species that have potential to occur in Mesa County, Colorado are described in Table 3 (USFWS 2017). Descriptions of potential occurrence and habitat descriptions are based on WestWater's knowledge of the area, documented occurrences by CNHP (Spackman et al. 1997), and geologic formations present in the surveyed area.

Table 3. Threatened and Endangered plants occurring in Mesa County, Colorado.

Common Name	Scientific Name	Status*	Habitat Preference
Colorado hookless cactus	*Sclerocactus glaucus*	T	Coarse soils on alluvial benches, rocky surfaces, and mesa slopes in desert shrub and pinyon-juniper woodland communities; 4,400 to 6,200 feet elevation. Known to occur in Mesa, Garfield, Delta, and Montrose Counties.
DeBeque phacelia	*Phacelia submutica*	T	Sparsely vegetated slopes on Atwell Gulch and Shire Members of the Wasatch Formation; 4,900 to 7,200 feet elevation. Known to occur in Mesa and Garfield Counties.

Observations

Colorado hookless cactus – WestWater biologists identified 65 Colorado hookless cacti within 100 meters of project features and an additional 26 cacti were observed beyond the 100-meter

survey buffer (Photo 1 and Figure 2). The majority of the plants were observed near the proposed road improvements associated with Phase 1A (20 cacti) and 14 cacti were observed within the sporting clays shooting range (Phase 1B) (Figures 2 and 3). A total of 17 cacti are located north of the proposed rifle/pistol shooting range with the nearest cactus approximately 59.3 meters from the edge of the shooting range. Cacti observed and distance to the proposed project features are described in Table 4. It should be noted that disturbance boundaries for Phases 1A and 1B were digitized in ArcGIS, and therefore, these distances may be subject to change if project shapefiles become available.

Photo 1: Colorado hookless cactus observed during surveys.

Table 4. Observed Colorado hookless cacti and distance to nearest project feature.

Quantity	Distance (Meters)	Project Feature
14	0	Sporting Clays Course (Phase 1B)
9	46.78	Road Improvements
1	50.37	Road Improvements
1	72.26	Rifle/Pistol Range (Phase 1A)
14	94.90	Rifle/Pistol Range (Phase 1A)
2	59.30	Rifle/Pistol Range (Phase 1A)
1	59.23	Road Improvements
1	73.21	Road Improvements
3	83.45	Road Improvements
1	61.95	Road Improvements
1	92.62	Road Improvements

Table 4. Observed Colorado hookless cacti and distance to nearest project feature.

Quantity	Distance (Meters)	Project Feature
1	97.14	Road Improvements
1	66.18	Road Improvements
7	64.32	Road Improvements
2	63.76	Road Improvements
1	69.19	Road Improvements
1	59.80	Road Improvements
2	87.29	Road Improvements
1	96.29	Road Improvements
1	92.66	Road Improvements
12	117.56	Rifle/Pistol Range (Phase 1A)
1	126.50	Rifle/Pistol Range (Phase 1A)
1	111.75	Road Improvements
2	108.70	Road Improvements
1	105.45	Road Improvements
2	109.23	Road Improvements
7	112.74	Road Improvements
91	**Total Plants**	

DeBeque Phacelia – DeBeque phacelia is dependent upon specific soil types associated with members of the Wasatch Formation (CNHP 1997). No outcrops of the Wasatch Formation were observed within 300 meters of project features during surveys.

RECOMMENDATIONS

A total of 65 cacti are located within 100 meters of project features and will require consultation with the USFWS prior to project construction. Of these, 41 cacti are located greater than 50 meters from currently planned project features. A total of 14 cacti (in a group) were documented to occur within the sporting clays shooting range, although this inclusion may be a result of the digitizing effort, and it is possible that they do not lie directly within the proposed disturbance boundary. There are 9 cacti located approximately 46.8 meters upslope from proposed road improvement/upgrades as the project is currently planned. With the exception of the cacti that lie within the disturbance boundary for Phase 1B, these plants have the greatest potential of being impacted by project construction and development activities. It is recommended that the road improvements for this section of road stay within the current limits of disturbance associated with the current road. WestWater does not recommend widening the road along this segment. Potential mitigation measures to limit impacts to Colorado hookless cactus may include (but are not limited to) the following:

- Avoid direct removal of cactus;
- Use fresh water free of chemicals for dust control;
- Restrict construction personnel to stay within construction limits;

- Plan footpaths and walkways to be greater than 50 meters from known cactus locations;
- Ensure that berms and backstops are large enough to prevent stray bullets from hitting the hillside, where cactus are known to occur, north of the Phase 1A shooting range;
- Avoid all uses of land (including placing shooting targets) within 20 meters of any known cactus locations; and
- Develop a multi-year monitoring plan for cacti within 50 meters of proposed project features.

Project coordination should occur between CPW and USFWS in order to develop appropriate conservation measures for the Colorado hookless cactus and their suitable habitats that occur in the project area.

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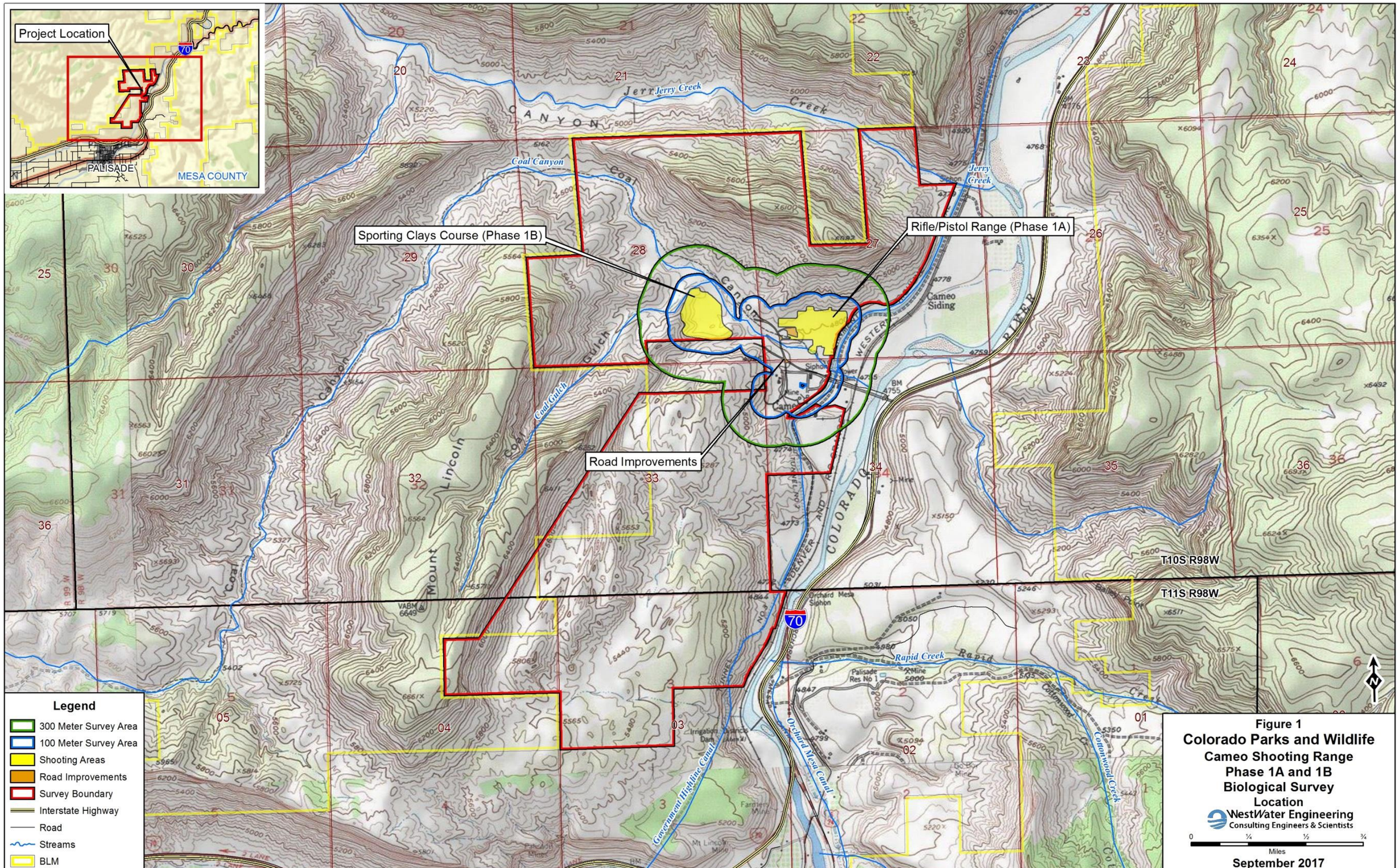


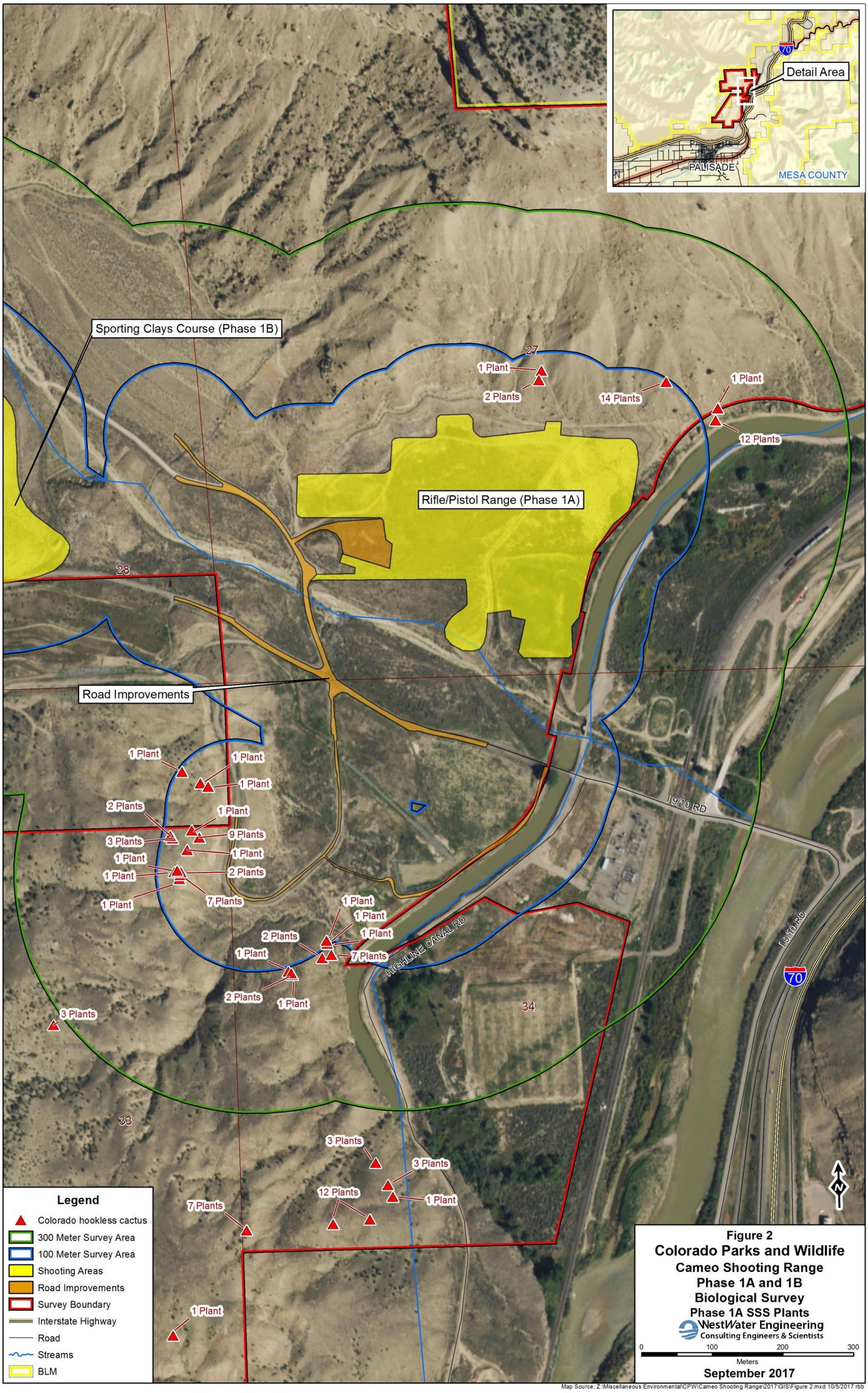
Figure 1
Colorado Parks and Wildlife
Cameo Shooting Range
Phase 1A and 1B
Biological Survey
Location

WestWater Engineering
Consulting Engineers & Scientists

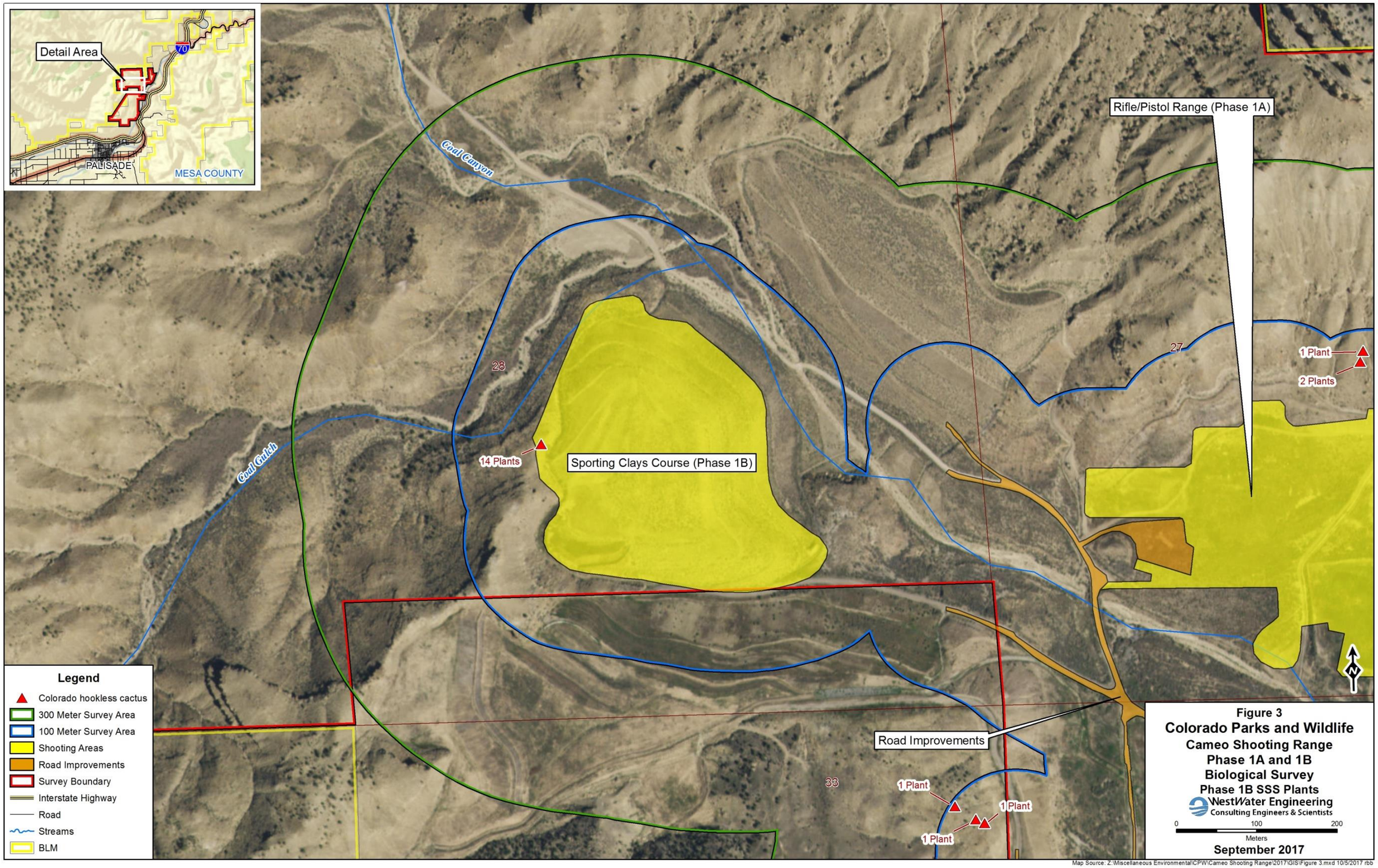
0 ¼ ½ ¾
Miles

September 2017

Map Source: Z:\Miscellaneous Environmental\CPW\Cameo Shooting Range\2017\GIS\Figure 1.mxd 9/29/2017 rbb



Map Source: Z:\Miscellaneous Environmental\CPW\Cameo Shooting Range\2017\GIS\Figure 2.mxd 10/5/2017 rbb



Map Source: Z:\Miscellaneous Environmental\CPW\Cameo Shooting Range\2017\GIS\Figure 3.mxd 10/5/2017 rbb

APPENDIX P -

CAMEO Cultural, Historical, and Archaeological Resources

The purpose of a cultural resource survey is to provide compliance under Section 106 of the National Historic Preservation Act (and its implementing regulations under 36 CFR Part 800) by undertaking a "reasonable and good faith" effort to identify historic properties (defined as listed on or eligible for listing on the National Register of Historic Places). Because the proposed Cameo Shooting Range development will use federal funds, and because part of the area of potential effects (APE) is on federal land administered by the Bureau of Land Management, Grand Junction Field Office (BLM GJFO), the project constitutes an undertaking as defined under 36 CFR 800.3. Federal undertakings require consideration of effects on historic properties before a permit is issued. Therefore, a Class I overview and a Class III cultural resource inventory of the proposed Cameo Shooting Range APE were conducted.

The project area is located on the west side of the Colorado River Canyon just north of the Town of Palisade east of Grand Junction. Relief in the APE is extreme, with elevations ranging from approximately 4750 feet above mean sea level (amsl) near the Colorado River at Cameo to about 6640 feet amsl on the southeastern flank of Mount Lincoln just 1.3 miles west of the river. Much of the APE is very steep and approximately 150 acres has been previously disturbed.

Prior to conducting the Class III inventory, a brief Class I overview of the proposed shooting range lease area was done. That overview included a formal files search of a similar but slightly smaller (1691.5 acres) APE footprint plus a one-mile buffer around it. Between the time of the Class I overview and the time of the Class III inventory, the APE was expanded to include 149.6 acres of BLM managed land and 38.9 acres of additional private land. Because of this change, another complete files search of the new APE plus a one mile buffer was conducted. In addition, an in-office files search of the same area was done at the BLM-GJFO on September 18, 2017. These files searches revealed a total of 41 previous cultural resource projects ranging in date from 1975 to 2016. Many of these 41 projects are related to coal or oil and gas extraction, but inventories were also done for water, range improvement, and transmission line developments.

The files searches also revealed 65 previously recorded cultural resources. Historic resources comprise the overwhelming majority of previous cultural resources in the search area. These resources include mines, mine complexes, or mining-related features, segments of the Denver & Rio Grande Western Railroad, water transport or storage sites (Government Highline Canal and ditch segments, among others), residential structures, a service station; transportation sites (roads and trails), electrical transmission lines, and others. Prehistoric resources in the search area include open camps, an open lithic scatter, and isolated finds.

The number of historic linear resources revealed in the search is worth noting. This is certainly due to the fact that the files search buffer includes part of the canyon along the Colorado River just north of Palisade. This canyon was a major transportation route historically and the presence

of the river provided a ready supply of water for numerous irrigation works, including the Government Highline Canal. Historic transportation features include the Denver & Rio Grande Western Railroad, U.S. Highway 6, and several local or regional roads. The historic Shoshone-Palisade Transmission line also passes through the search area.

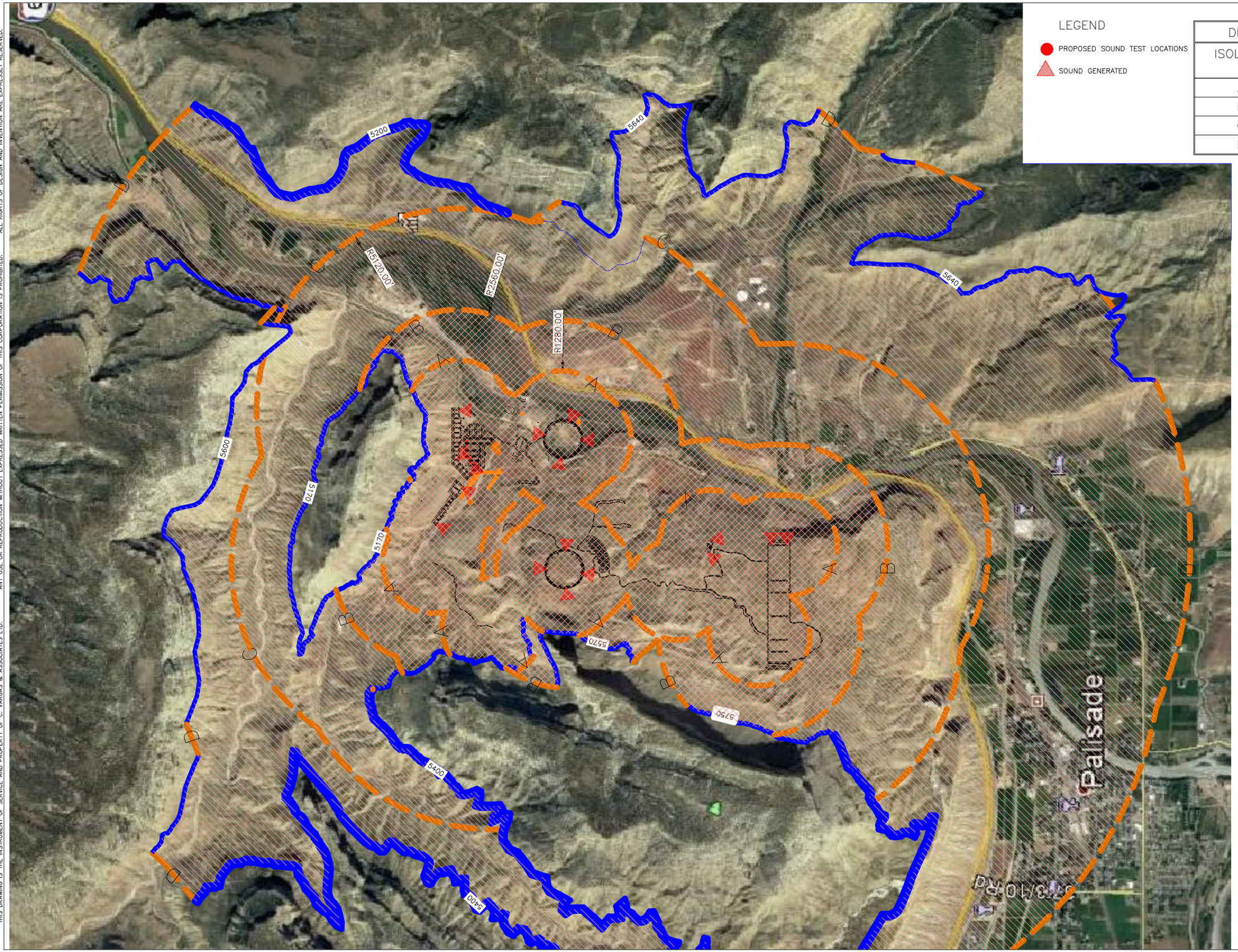
The APE was inventoried for cultural resources between September 20th and October 4th, 2017. Per Colorado State and BLM guidelines, standard pedestrian inventory transects were no greater than 20 meters apart. However, for a variety of reasons, parts of the 1880 acre APE were either excluded from systematic inventory or were inventoried by walking more widely spaced transects. Of the 587.4 acres excluded from systematic coverage, the majority (n=398.8 acres) was excluded due to steep slopes; 153.0 acres were excluded because they had already suffered total surface disturbance; 31.7 acres were excluded because they were situated directly behind an active shooting range; and 3.9 acres were excluded due to impenetrable vegetation. Areas covered at greater than a 20 meter interval included steep, but not inaccessible slopes, typically between approximately 20 and 30 degrees in slope, and encompassed approximately 571.3 acres of the APE. The remaining 721.4 acres were inventoried by walking 20 meter transect intervals.

Inventory resulted in updates to the documentation on five previously recorded sites and discovery of 14 new sites and 25 isolated finds. Updates included two segments of the historic Government Highline Canal, one rock art site that could not be relocated, and two historic structures that have been destroyed. New sites include one new segment of the Government Highline Canal, one segment of Coal Canyon Road, two segments of an unnamed historic road, one multi-component rock art site with both prehistoric and historic artifacts, three historic structures in the vicinity of the former Cameo Town site (now destroyed), one historic rock shelter, two sites with historic animal control features, two historic trash scatters, and one site with historic foundations and a trash scatter.

As with the sites, the vast majority (n=21 or 84%) of the isolated finds is historic in age. Three isolates are prehistoric and one is of unknown age and cultural affiliation. Nine of the finds are cadastral survey markers, most of which date to the 1950s. One of the markers, however, was placed in 1908. The remaining historic isolates consist largely of small scatters of trash or makeshift hunting blinds. Prehistoric isolated finds include two small, limited activity chipped stone loci and one cairn/rock pile estimated to be prehistoric because of sedimentation and lichen cover.

All of the isolated finds are recommended as not eligible for inclusion on the National Register of Historic Places (NRHP). The previously recorded and new segments of the Government Highline Canal are recommended as supporting elements of the overall resource, which has been evaluated as officially eligible for the NRHP. Following Colorado State Historic Preservation Office protocol, the two newly recorded historic roads are recommended as eligible for the NRHP because they have not been recorded in their entirety. The recorded segments, however, are recommended as not supporting the overall potential eligibility of the larger resources. Of

the remaining 13, non-linear resources, nine are recommended as not eligible for the NRHP, three are recommended as eligible, and one is recommended as "needs data." One of the eligible sites is a multi-component rock art site that includes panels of both prehistoric and unknown age, as well as prehistoric and historic artifacts. Another is a structure with a small trash scatter in the vicinity of the destroyed Cameo Town site. The third eligible site consists of a brush fence and corral with a historic trash dump, that could not be recorded in its entirety because part of it extends onto private land outside the APE. The portion of this site within the APE is recommended as a non-supporting element of the larger site. The one "needs data" recommendation pertains to a structure in the vicinity of the Cameo Town site that could be photographed, but not recorded in detail because it is apparently radioactive.



LEGEND

- PROPOSED SOUND TEST LOCATIONS
- SOUND GENERATED

DISTANCE PRESSURE TABLE		
ISOLINE	RADIUS	DECIBEL LEVEL
A	1,280	72
B	2,560	66
C	5,120	60
D	10,240	54

SOUND STUDY
SCALE: 1" = 1,200'

GRAPHIC SCALE
1200 0 600 1200 2400
(IN FEET)
1 inch = 1200ft.

NOTE:

1. AERIAL PHOTOGRAPH SHOWN HEREON WAS TAKEN FROM GOOGLE EARTH.

G-27

NOTE: If this drawing is printed 11"x17", this drawing is NOT TO SCALE or 1/2 SCALE

DRAFT CONCEPTUAL PLANS 2/22/17

NO.	REVISION	DATE	BY

TABLE TOP MODEL
SOUND STUDY

CAMEO SHOOTING AND EDUCATION COMPLEX

C. VARGAS & ASSOCIATES, LTD.
CONSULTING ENGINEERS
AND LAND SURVEYORS
JACKSONVILLE, FLORIDA 32211
PHONE (904) 725-3727 FAX (904) 725-3297
CERT. OF AUTH. NO.0000278

DRAWN BY	CHECKED BY	DATE
D.M.	C. VARGAS	02-06-17

SUBMITTED BY	REG. ENGR. NO.
	38019

C.A.D.D. FILE

PROJECT NO. **16012.01**

SHEET

OF

DO NOT SCALE DRAWINGS

NOT APPROVED FOR CONSTRUCTION DATE:

COLORADO GEOLOGICAL SURVEY

1801 19th Street
Golden, Colorado 80401

Karen Berry
State Geologist

August 18, 2016

Christie Barton
Mesa County Planning Division
P.O. Box 20,000
Grand Junction, CO 81502

Location:
Sections 27, 28, 33, and 34,
T10S, R98W of the 6th P.M.
39.1483, -108.3175

Subject: Cameo Sport Shooting and Education Complex – Conditional Use Permit Application 2016-0136 CUP; Mesa County, CO; CGS Unique No. MA-16-0018_2

Dear Christie:

Colorado Geological Survey has reviewed the Cameo Sport Shooting and Education Complex CUP referral. I understand the applicant seeks a conditional use permit for an outdoor shooting range and associated uses, to be managed by Colorado Parks and Wildlife, on approximately 1750 acres located about 2.5 miles north of Palisade, on the west side of I-70 and the Colorado River.

CGS has no objection to approval of the conditional use permit application as proposed.

Mapped landslide. The proposed campground and shotgun, archery, and rifle ranges as indicated on the Cameo Shooting Range Concept Plan (Colorado Parks and Wildlife, February 2015) are located within a large mapped landslide (Colton et al, 1975, Preliminary map of landslide deposits, Grand Junction 1° x 2° quadrangle, Colorado and Utah: U.S.G.S. Miscellaneous Field Studies Map MF-697, scale 1:250,000). The applicant, the Town of Palisade, and Colorado Parks and Wildlife should be made aware that seismic activity or an exceptionally heavy or prolonged rainfall or snowmelt event could result in destabilization and slope movement of unknown extent and magnitude. It is not possible to determine the probability or predict the magnitude of future landslide activity, and stabilization of a landslide complex this large is impractical. **The proposed recreational, low intensity uses are appropriate for this terrain.**

Cameo Mine, mine openings, and potential methane hazard. The proposed "Building Sites" area contains several adits and shafts associated with the Cameo Mine. CGS Inactive Coal Mine map of the Cameo quadrangle indicates that the Cameo is a "gassy mine", with a potential risk of methane explosion. Mine openings also present a significant risk of instability and subsidence. CGS does not know the current status of these mine openings. To reduce hazards to users and improvements, all mine openings on the site that have not already been stabilized and sealed, should be plugged/stabilized and sealed in accordance with Division of Reclamation, Mining and Safety (DRMS) standards as outlined in *Best Practices in Abandoned Mine Land Reclamation: the remediation of past mining activities* (http://mining.state.co.us/SiteCollectionDocuments/AMLbmp.pdf).

There are no *known* mine openings or undermining in the vicinity of the proposed campground area.